THE JOURNAL and CERAMIC ABSTRACTS

AMERICAN CERAMIC SOCIETY

APRIL • 1941

MONTHLY PUBLICATION DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES

TABLE OF CONTENTS

Vol. 24 April, 1941 No. 4

THE JOURNAL

System Sodium Disilicate–Barium Disilicate.....111–16
By K. T. Greene and W. R. Morgan

X-Ray Study of Lime-Phosphate and Lime-Borate Glass.....116–19
By J. Biscoe, A. G. Pincus, C. S. Smith, Jr., and B. E. Warren

Durability of Optical Glass.....119–22
By Frank L. Jones

Effect of Composition and Thermal History on Dielectric Constants of Soda-Borosilicate Glasses.....123–30
By J. M. Humphrys and W. R. Morgan

Further Studies of Glass Fracture with High-Speed Photography.....131–37
By H. E. Edgerton and F. E. Barstow

Factors Affecting Sagging Tests on Enameling Iron.....137–40
By J. E. Sams, William McGohan, and J. J. Canfield

Use of a High Sericite Pyrophyllite in Vitreous Bodies.....141–44
By E. W. Emrich

CERAMIC ABSTRACTS

20—4

Abrasives..... 79
Art and Archeology..... 80
Cements..... 83
Enamel..... 83
Glass..... 87
Structural Clay Products..... 93
Refractories..... 94
Terra Cotta..... 97
Whiteware..... 97
Equipment and Apparatus..... 98
Kilns, Furnaces, Fuels, and Combustion..... 100
Geology..... 101
Chemistry and Physics..... 104
General..... 105

Publication Office: 20th & Northampton Sts., Easton, Pa.
Editorial Office: 2525 N. High St., Columbus, Ohio
Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published monthly.
Subscription fifteen dollars ($15.00) a year. Single numbers $1.50
(Foreign and Canadian postage, 50¢ additional on subscriptions)
(Copyright 1941, American Ceramic Society, Inc.)

THE SYSTEM SODIUM DISILICATE–BARIUM DISILICATE*

By K. T. Greene and W. R. Morgan

Abstract

The sodium disilicate-barium disilicate join of the ternary system, Na_2O–BaO–SiO_2, has been studied by means of the quenching method, and the phase-equilibrium diagram has been determined. The two compounds form a binary system without intermediate compounds and without appreciable solid solution. The eutectic occurs at approximately 32% of barium disilicate by weight and at a temperature of 797°C. The melting point of barium disilicate was determined as 1418°C. The glasses in the field of stability of barium disilicate show a marked tendency toward devitrification.

The refractive indices of the glasses for sodium light were measured by the microscopic immersion method. These varied regularly from 1.505 for sodium disilicate glass to 1.610 for barium disilicate glass. The refractive index-composition curve plotted on a weight percentage basis is definitely convex downward, whereas on a mol percentage basis it is slightly convex upward.

I. Introduction

Barium oxide is a common constituent of commercial glasses, particularly of optical glasses, yet the phase-equilibrium relations of silicate systems containing this oxide have as yet been only incompletely determined. In the majority of glasses, barium oxide is a minor ingredient, seldom being present to the extent of more than a few per cent. In certain types of optical glasses, such as barium crowns, however, the content may reach 50% by weight.

The occurrence of barium disilicate as a devitrification product of barium crown optical glass has been reported and described by Bowen.[1] Mention of this crystalline compound is also frequently encountered elsewhere in the literature on devitrification. A study was therefore undertaken of mixtures on the sodium disilicate-barium disilicate join of the ternary system, Na_2O–BaO–SiO_2, with a view to adding to the knowledge of the devitrification of barium glasses. Some of these compositions resemble certain barium crowns, although they are considerably less complex.

II. Historical Data

The mention of barium disilicate by Bowen[1] seems to be the earliest in the literature. The crystals he observed in optical glass were identified as this compound by comparison with crystals obtained from a melt of the composition $BaO \cdot 2SiO_2$. Bowen obtained somewhat lower refractive indices on the crystals which formed in optical glass than on those resulting from crystallization of the pure barium disilicate melt. This difference was considered to be due possibly to a small amount of alkali disilicate in solid solution, potassium disilicate being the most probable because of its crystallographic similarity to barium disilicate.

The crystals occurring in optical glass are described as elongated hexagonal plates having terminal angles of about 100° and lateral angles of about 130°. The extinction is parallel and the optical character is biaxial negative, indicating that the crystal system is orthorhombic. The elongation is always negative, and the optic plane is parallel to the platy development. The axial angle, $2V$, equals approximately 70°. The refractive indices are $\gamma = 1.613$ and $\alpha = 1.595$, as measured in immersion liquids under the microscope. The indices of crystals, obtained by cooling a pure barium disilicate melt, were $\gamma = 1.617$ and $\alpha = 1.595$. The other optical properties were identical, and the melting point of the pure compound, which was found to be congruent, was determined as 1426°C. by means of heating curves.

Eskola[2] describes barium disilicate obtained in the system BaO–SiO_2. The crystals differ in minor details from those of Bowen. The crystal system is confirmed as orthorhombic, but instead of the six-sided plates, Eskola observed rectangular crystals of pinacoidal habit. The optic plane is the macropinacoid 100 and the character is negative. The axial angle, $2V$, equals 75°. The refractive indices are $\gamma = 1.621$, $\beta = 1.612$, and $\alpha = 1.597$. Except for the difference in habit and slightly higher refractive indices, the agreement with Bowen's crystals is good. The Eskola value for the melting point is 1420 ± 4°C., determined by the quenching method.

The binary system, Na_2O–SiO_2, has been determined by Morey and Bowen[3] and by Kracek.[4] The compound, sodium disilicate, described by them is of particular interest in the present work. It occurs as orthorhombic plates and needles. The plates are parallel to the 100 face. The optic plane is parallel to 010, the brachypinacoid, with an axial angle of 50° to 55°.

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 9, 1940 (Glass Division). Received July 2, 1940.

Based on a thesis submitted by Kenneth T. Greene in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Rutgers University, New Brunswick, N. J., June, 1940.

[1] (*a*) N. L. Bowen, "Crystals of Barium Disilicate in Optical Glass," *Jour. Wash. Acad. Sci.*, **8**, 265–68 (1918). (*b*) N. L. Bowen, "Devitrification of Glass," *Jour. Amer. Ceram. Soc.*, **2** [4] 261–78 (1919).

[2] Pentti Eskola, "Silicates of Strontium and Barium," *Amer. Jour. Sci.*, [5] **4**, 331–75 (1922); *Ceram. Abs.*, **2** [4] 83 (1923).

[3] G. W. Morey and N. L. Bowen, "Binary System Sodium Metasilicate-Silica," *Jour. Phys. Chem.*, **28** [11] 1167–79 (1924); *Ceram. Abs.*, **4** [5] 127 (1925).

[4] F. C. Kracek, "System Sodium Oxide–Silica," *Jour. Phys. Chem.*, **34** [7] 1583–98 (1930); *Ceram. Abs.*, **9** [10] 881 (1930).

The optical character is negative with the following refractive indices: $\gamma = 1.508$, $\beta = 1.505$, and $\alpha = 1.497$. The melting point is congruent and has been well established at 874°C.

Data on the ternary system, Na_2O–BaO–SiO_2, for the most part are limited to measurements of various physical properties of the glasses. In this connection, the extensive work of Peddle[5] on optical properties and devitrification is the most important. The results indicate that the crystalline products obtained in the range of composition studied were silica and a barium silicate which was considered to be the disilicate. This compound occurred as spherulites, needles, or platy crystals, depending on the heat treatment given the glass.

In the early work of Wallace[6] on silicate mixtures, the system, $Na_2O \cdot SiO_2$–$BaO \cdot SiO_2$, was studied by means of cooling curves, and his results indicate a continuous series of mixed crystals throughout the composition range. The cooling-curve method has been shown since to give unreliable and often erroneous results when it is applied to silicates because of the tendency toward undercooling to which they are subject. Few of the conclusions by Wallace from experiments on other silicate systems have been substantiated in later work.

III. Preliminary Work

(1) Materials

In the study of the phase-equilibrium relations of silicates, materials of the highest obtainable purity must be used because the liquidus temperatures may be altered considerably by the presence of small amounts of foreign oxides. Batch materials used in these studies, therefore, were of proved satisfactory purity as obtained or they were purified by special treatment.

The silica was prepared from a Sylvania sandstone of a rather high initial purity, using essentially the method of purification described by Faust and Peck.[7] This method requires treatment with dilute acids, the removal of heavy mineral particles with bromoform, heating to about 1400°C. for several hours, crushing, and washing a second time with acids. Two batches of silica were prepared and were analyzed by evaporation with hydrofluoric and sulfuric acids, with subsequent ignition with ammonium carbonate. The nonvolatile residues were, respectively, 0.06 and 0.04%.

Anhydrous sodium carbonate of reagent grade supplied the sodium oxide component. Qualitative tests for impurities were made according to the specifications of Murray.[8] These tests were negative, except that for potassium, which showed a fairly strong violet flame when viewed through cobalt glass. The sodium carbonate was analyzed volumetrically, giving values of 99.92% of Na_2CO_3 or 58.44% of Na_2O.

The barium oxide was introduced as specially purified barium carbonate. The starting point was the reagent, barium nitrate, which was purified by a double recrystallization from distilled water. Barium carbonate was precipitated from the nitrate solution by addition of the reagent, ammonium carbonate. The product, after thorough washing, was dried and heated in platinum at 250° to 300°C. to volatilize any of the remaining ammonium salts. This carbonate was analyzed by precipitating the barium as sulfate, with results of 99.92% of $BaCO_3$ or 77.64% of BaO.

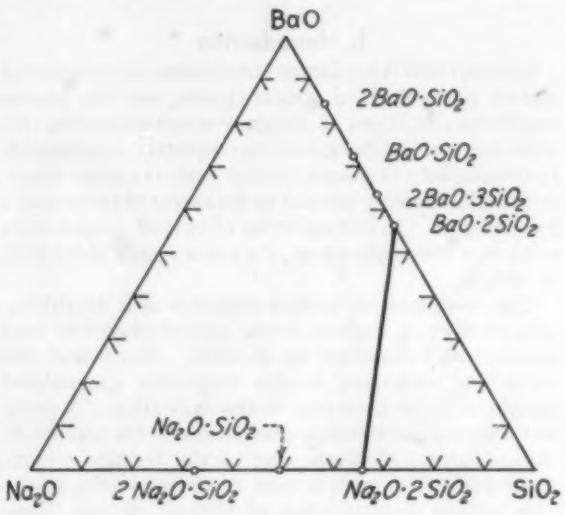

FIG. 1.

(2) Preparation of Glasses

The series of glasses to be studied was made by preparing sodium disilicate and barium disilicate glasses and blending these end members in various proportions. The disilicate mixtures were melted in a platinum crucible after careful weighing and mixing of the batch materials. In the case of the sodium disilicate glass, special precautions were taken to keep the volatilization of soda as low as possible.[4] A weighing of the crucible and glass after the first melting showed that the departure from the theoretical weight was small. The sodium and barium disilicate glasses were each crushed in a diamond steel mortar to pass a No. 30 sieve and then were remelted two additional times. A magnet was run through the glass after each crushing to remove particles of steel abraded from the mortar.

The intermediate compositions were made up by weighing carefully the correct proportions of the end members and mixing and melting in platinum. These

[5] (*a*) C. J. Peddle, "Development of Various Types of Glass: XII, Interaction of Silica, Sodium Oxide, and Barium Oxide," *Jour. Soc. Glass Tech.*, **5**, 201–11 (1921); *Ceram. Abs.*, **1** [6] 165 (1922).
(*b*) C. J. Peddle, Defects in Glass, pp. 92–93, 110–12, 114–22, 132–33. Glass Publications, Ltd., London, 1927; *Ceram. Abs.*, **6** [10] 485 (1927).

[6] (*a*) R. C. Wallace, "Binary Systems of Sodium Metasilicate with Lithium, Magnesium, Calcium, Strontium, and Barium Metasilicate, etc.," *Z. anorg. allgem. Chem.*, **63** [1] 1–48 (1909).
(*b*) R. C. Wallace, "High-Temperature Work on the Silicates," *Trans. Ceram. Soc.* [English], **9**, 172–97 (1910).

[7] G. T. Faust and A. B. Peck, "Refractive Indices of Some Glasses in Ternary System $K_2O \cdot 4SiO_2$–Fe_2O_3–SiO_2," *Jour. Amer. Ceram. Soc.*, **21** [9] 320–24 (1938).

[8] B. L. Murray, Standards and Tests for Reagent and C. P. Chemicals, 2d ed., pp. 441–46. D. Van Nostrand Co., Inc., New York, 1927; *Ceram. Abs.*, **7** [4] 261 (1928).

glasses were crushed, remelted, and recrushed four times. They were then examined in immersion liquids under the microscope and were found to be homogeneous. The compositions studied, in terms of weight percentage of sodium disilicate and barium disilicate and also of the three constituent oxides, are given in Table I. Figure 1 shows the relation to the more general three-component system, Na_2O–BaO–SiO_2.

(3) Analysis of Glasses

The compositions of the disilicate end members were checked by simplified analytical procedures, which are justified by the degree of purity of the ingredients. The sodium disilicate glass was analyzed by a method used by Morey and Bowen,[8] which is similar to a procedure described by Morey and Fenner[9] for the analysis of potassium silicates. The method consists of decomposing the glass with hydrofluoric acid and converting the soda to Na_2SiF_6, which is weighed. Two samples of the glass so analyzed gave values of 34.06 and 34.04% of Na_2O; the theoretical composition is 34.04%.

The barium disilicate glass was analyzed by a short method which gave satisfactory results. The powdered

TABLE I

COMPOSITIONS OF MIXTURES

No.	$Na_2O \cdot 2SiO_2$	$BaO \cdot 2SiO_2$	Na_2O	BaO	SiO_2
100	100.0	0	34.0	0	66.0
110	90.0	10.0	30.6	5.6	63.8
120	80.0	20.0	27.2	11.2	61.6
130	70.0	30.0	23.8	16.8	59.4
132	68.0	32.0	23.1	18.0	58.9
140	60.0	40.0	20.4	22.4	57.2
150	50.0	50.0	17.0	28.0	55.0
160	40.0	60.0	13.6	33.7	52.7
170	30.0	70.0	10.2	39.3	50.5
180	20.0	80.0	6.8	44.9	48.3
190	10.0	90.0	3.4	50.5	46.1
200	0	100.0	0	56.1	43.9

sample was evaporated twice with hydrofluoric acid and an excess of sulfuric acid over that required to react completely with the barium to form sulfate. The excess acid was fumed off, and the barium sulfate was ignited to constant weight at a dull red heat. The results on two samples were 56.11 and 56.10% of BaO, which are to be compared with the theoretical figure of 56.08%.

Because the compositions of the end members were so nearly equal to the desired compositions, analyses of the intermediate mixtures were unnecessary. Their compositions were taken to be equal to the values calculated from the proportions of the end members used.

(4) Refractive-Index Measurements

In connection with the homogeneity tests, refractive-index measurements were made on the glasses by the microscopic-immersion method. A sodium flame provided illumination, and an Abbé refractometer was used to check the indices of the immersion liquids immediately after use. The refractive-index data are presented in Table II, and Fig. 2 shows graphically the relation between composition and refractive index. The lower curve results from plotting on a weight percentage basis, whereas the upper curve is on a mol percentage basis. The accuracy of the measurements is about ±0.002.

TABLE II

REFRACTIVE INDICES OF GLASSES

No.	Refractive index	No.	Refractive index
100	1.505	160	1.560
110	1.513	170	1.571
120	1.520	180	1.583
130	1.529	190	1.597
140	1.539	200	1.610
150	1.549		

The weight percentage curve has a pronounced convexity downward, which is to be expected from the relatively high molecular weight of barium disilicate. The curvature of the mol percentage curve is much less; it is not straight, however, as there is a small but definite convexity upward. All of these measurements were made on quenched, not annealed, glasses (the indices on annealed samples might be appreciably different from those reported here).

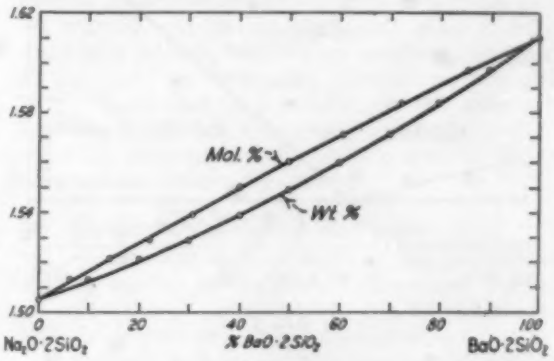

FIG. 2.

IV. Quenching Determinations

(1) Method and Apparatus

The phase relations of the mixtures were determined entirely by the quenching method, which was first employed by Shepherd, Rankin, and Wright[10] and which has been described in various papers from the Geophysical Laboratory.[11] A small quantity of the pulverized silicate is wrapped in platinum foil and maintained at a constant temperature long enough for equilibrium to have been reached. The charge is quickly cooled, usually by quenching in mercury in order to "freeze in" the condition of the material existing at the temperature of the furnace. A microscopic examination reveals the number and identity of the phases

[9] G. W. Morey and C. N. Fenner, "Ternary System Water–Potassium Silicate–Silica," *Jour. Amer. Chem. Soc.*, **39** [6] 1173–1229 (1917).

[10] E. S. Shepherd, G. A. Rankin, and F. E. Wright, "Binary Systems of Alumina with Silica, Lime, and Magnesia," *Amer. Jour. Sci.*, [4] **28**, 293–333 (1909).

[11] G. W. Morey, "Devitrification of Soda-Lime-Silica Glasses," *Jour. Amer. Ceram. Soc.*, **13** [10] 683–713 (1930).

which were present in equilibrium at the higher temperature. By running a series of quenchings at different temperatures, it is possible to locate the liquidus or other significant temperature of a silicate within a rather narrow range.

The furnace and temperature-control device used were of the type developed at the Geophysical Laboratory[12]; they have also been described in detail by Faust.[13] The furnace was a platinum-wound vertical tube type having a central "hot spot" with a temperature gradient of less than 0.5°C. over a length of 1 cm. The charge and measuring thermoelement were located in this zone and about 1 or 2 mm. apart. The thermoregulator was capable of maintaining the temperature constant to within 0.5°C. for the longest necessary periods of time. The charge was suspended in the furnace by a fine platinum wire which could be fused by passing through it a heavy electric current, thus allowing the sample in its platinum envelope to drop into a dish of mercury.

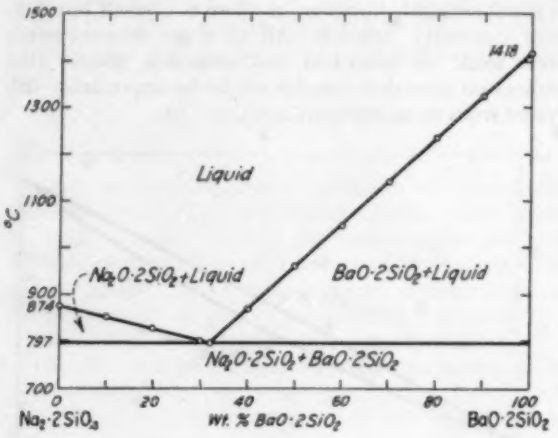

FIG. 3.

(2) Temperature Measurements

The temperatures of the furnace and charge were measured with a platinum to 90% platinum-10% rhodium thermoelement and a Leeds and Northrup type K–2 precision potentiometer. The cold junction of the thermoelement was maintained in an ice bath in a Dewar flask, from which copper leads were run to the potentiometer. The standard cell was kept in an insulated box to protect it as much as possible from nonuniform room temperatures. To minimize the effect of the thermal e.m.f. originating in the potentiometer itself, commutating switches were used whereby reversed as well as normal readings could be taken with the potentiometer and battery circuits. The average of the normal and reversed readings was taken as the true one because the undesired e.m.f. is added to the true value in one case and subtracted in the other. The difference between normal and reversed readings was rarely greater than 3 or 4 microvolts.

The thermoelement was calibrated periodically at the following fixed melting points, the temperatures being defined on the Geophysical Laboratory scale: NaCl 800.4°C., Au 1062.6°C., and $CaO{\cdot}MgO{\cdot}2SiO_2$ (diopside) 1391.5°C.

The sodium chloride was specially purified, starting with the analytical reagent and recrystallizing twice from fresh distilled water. The gold, intended for thermometric calibrations, had a fineness of not less than 999.8. The diopside was supplied by the Geophysical Laboratory, where it is regularly used as a calibration standard.

The potentiometer readings of the e.m.f. were converted to temperatures with a deviation curve and standard tables.[14] The accuracy of the measurements depends largely on the calibration of the thermoelement. The fixed points in this work were determined with a maximum probable error of about ±0.3°C. The potentiometer, however, could be read with a precision corresponding to about 0.1°C.

(3) Results

A large number of quenching experiments was performed in the process of locating the liquidus temperatures of the various compositions. Many of the temperatures tried at first were considerably too high or too low. These results are not included in this report because they contribute no information not obtainable from the data given. The quenching results which serve to define the liquidus curve for the system are presented in Table III; the graphic representation of the same data is the equilibrium diagram (Fig. 3).

V. Discussion of Results

(1) Equilibrium Diagram

The phase-equilibrium diagram is simple in type and requires little explanation. One unusual feature is the remarkable straightness of both liquidus curves. A greater degree of curvature is commonly observed in silicate systems. The sodium disilicate-barium disilicate join comprises a true binary system, inasmuch as no crystalline phases occur whose compositions are not found on this line. In fact, only the two end members appear as solid phases in this simple eutectic system. With the addition of barium disilicate, the liquidus curve of sodium disilicate slopes down from the melting point at 874°C. until the binary eutectic is reached at 797°C. This point occurs at slightly less than 32% of barium disilicate by weight. The liquidus of the barium disilicate then rises rather steeply to the melting point of the pure compound, determined as 1418°C.

[12] (*a*) L. H. Adams, "Thermostats for Very High Temperatures," *Jour. Optical Soc. Amer.*, **9** [5] 599–603 (1924); *Ceram. Abs.*, **4** [8] 224 (1925).
(*b*) H. S. Roberts, "Geophysical Laboratory Furnace Thermostat," *Jour. Optical Soc. Amer.*, **11** [2] 171–86 (1925).

[13] G. T. Faust, "Fusion Relations of Iron-Orthoclase with Discussion of Evidence for Existence of an Iron-Orthoclase Molecule in Feldspars," *Amer. Mineralogist*, **21** [12] 735–63 (1936); *Ceram. Abs.*, **16** [5] 161 (1937).

[14] W. F. Roeser and H. T. Wensel, "Reference Tables for Platinum to Platinum-Rhodium Thermocouples," *Bur. Stand. Jour. Research*, **10** [2] 275–87 (1933); R. P. 530; *Ceram. Abs.*, **12** [5] 198 (1933).

(2) Attainment of Equilibrium

Equilibrium is reached much more slowly for compositions in the field of sodium disilicate than for those in which barium disilicate is the primary phase. Longer periods of time, therefore, were required for the determinations. According to Kracek,[4] sodium disilicate reaches equilibrium in th esystem, Na_2O–SiO_2, in from 2 to 5 hours. In the present work, therefore, 5-hour runs were made on charges in the sodium disilicate field. These mixtures may be quenched in air merely by lifting them quickly from the furnace.

Barium disilicate, on the other hand, exhibits a strong tendency to crystallize from compositions in its field, and the periods of time the charges were held at constant temperature were much shorter. Runs of $^1/_2$ to 1 hour were found to be sufficient in all cases. Mixtures from which barium disilicate crystallizes as the primary phase must be quenched in mercury to obtain a rapid enough cooling.

The test for the attainment of equilibrium consists in running two charges at the same temperature; one charge is the original glass, and the other contains crystals. Equilibrium is proved if the same final condition is reached in the same period of time for both cases. This test was applied to several compositions in the fields of sodium disilicate and barium disilicate in order to insure that sufficient time was being allowed.

Charges which originally contain both crystals and glass are preferred for quenching experiments because the liquidus can be determined more sharply. Small, well-distributed crystals are necessary, however, because large ones pass into solution very slowly in a viscous glass. The compositions in the field of sodium disilicate accordingly were devitrified before quenching runs were made. This treatment, however, was found to be unnecessary for glasses from which barium disilicate is the first to crystallize inasmuch as they devitrify during the time that they are being heated to the furnace temperature.

TABLE III

RESULTS OF QUENCHINGS

No.	Time (hr.)	Temp. (°C.)	Final condition
100		874	Melting point[3,4]
110	5	850	Some $Na_2O \cdot 2SiO_2$ in glass
	$5^1/_2$	853	All glass
	Liquidus	851	
120	5	826	Considerable $Na_2O \cdot 2SiO_2$ in glass
	5	830	All glass
	Liquidus	828	
130	5	795	$Na_2O \cdot 2SiO_2$ and $BaO \cdot 2SiO_2$ with some glass
	5	799	Some $Na_2O \cdot 2SiO_2$ in glass
	5	802	Rare " " "
	5	804	All glass
	Liquidus	803	
132	5	792	$Na_2O \cdot 2SiO_2$ and $BaO \cdot 2SiO_2$ with some glass
	$5^1/_2$	796	Rare $Na_2O \cdot 2SiO_2$ and $BaO \cdot 2SiO_2$ in glass
	5	798	Very rare $BaO \cdot 2SiO_2$ in glass
	5	800	All glass
	Eutectic	797	
	Liquidus	799	
140	$1^1/_2$	868	Extremely rare $BaO \cdot 2SiO_2$ in glass
	1	870	All glass
	Liquidus	869	
150	$^1/_2$	963	Very rare $BaO \cdot 2SiO_2$ in glass
	$^3/_4$	965	All glass
	Liquidus	964	
160	$^3/_4$	1049	Very rare $BaO \cdot 2SiO_2$ in glass
	$1^1/_2$	1052	All glass
	Liquidus	1050	
170	1	1137	Very rare $BaO \cdot 2SiO_2$ in glass
	$2^1/_2$	1141	All glass
	Liquidus	1139	
180	1	1234	Rare $BaO \cdot 2SiO_2$ in glass
	1	1237	All glass
	Liquidus	1236	
190	1	1325	Rare $BaO \cdot 2SiO_2$ in glass
	1	1328	All glass
	Liquidus	1327	
200	1	1417	$BaO \cdot 2SiO_2$ in some glass
	1	1419	All glass
	Melting point	1418	

(3) Accuracy of Liquidus Determinations

The accuracy of the liquidus determinations is not as great as that of the actual temperature measurements. It is governed by the magnitude of the smallest temperature interval which will allow a definite distinction between the presence or absence of crystals in the glass. In most cases, this interval was about 3° or 4°C., so that the maximum probable error in the liquidus temperatures reported is of the order of ±2.3°C.; this includes the possible error in the two temperatures limiting the interval.

(4) Description of Crystalline Phases

The compound, sodium disilicate, occurred usually as laths, needles, or long prismatic crystals. The optical properties as determined in this work agree well with the descriptions given in the literature.[3,4]

The optical properties of the barium disilicate crystals obtained agree with those of Eskola,[2] but they differ slightly in certain respects from those of Bowen.[1] The refractive indices determined were $\gamma = 1.619$ and $\alpha = 1.598$. Pinacoidal crystals and those of six-sided platy habit were observed. The angles on the latter type were measured with the microscope, but owing to the small size of the crystals they may be somewhat in error; these values are approximately 125° and 110°. In other respects, they closely resemble Bowen's crystals.

The two rather distinct types of barium disilicate crystals suggested the possibility of two definitely different polymorphic forms, especially in view of the fact that the six-sided plates were observed near the lower liquidus temperatures, whereas the pinacoidal crystals tended to form at the higher temperatures near the barium disilicate side. A series of quenchings made over a considerable range of temperature, however, showed both types to be capable of existing side by side. It may be concluded from this that they represent crystals of different external habit but of identical internal structure. This conclusion is also substantiated by

the fact that no difference in refractive indices could be detected.

The possibility of solid solution of sodium disilicate in barium disilicate was carefully investigated, but no evidence for this was found. If such were actually the case to any appreciable extent, the refractive indices of barium disilicate would certainly be lowered. The indices of the crystals separating near the eutectic, however, are the same as those of the pure compound within the accuracy of measurement of the immersion method.

VI. Conclusions

The sodium disilicate-barium disilicate join of the ternary system, Na_2O–BaO–SiO_2, is a true binary system of the simple eutectic type, with no intermediate compounds in the range of temperatures studied.

The binary eutectic occurs at approximately 32% of barium disilicate by weight and at a temperature of 797°C.

From a consideration of refractive-index measurements, there is no appreciable solid solution in the system.

Two types of barium disilicate crystals occur in this system. They differ only in external habit rather than exist in distinct polymorphic forms.

Acknowledgment

The authors wish to thank G. W. Morey of the Geophysical Laboratory for suggesting the study of this system and for valuable advice concerning the experimental procedure. They are also indebted to W. C. Taylor of the Corning Glass Works for advice on the preparation of pure barium carbonate.

Department of Ceramics
Rutgers University
New Brunswick, New Jersey

X-RAY STUDY OF LIME-PHOSPHATE AND LIME-BORATE GLASS*

By J. Biscoe,† A. G. Pincus,‡ C. S. Smith, Jr., and B. E. Warren

Abstract

X-ray diffraction patterns have been made of two lime-phosphate glasses with compositions of 23% and 28% of CaO by weight, and of one lime-borate glass with 25% of CaO. Fourier analyses of these patterns were carried out, and the radial distribution curves were plotted. In the lime-phosphate glasses, each phosphorus is tetrahedrally bonded to 4 oxygens at a distance of 1.57 A, and each oxygen is bonded to either 1 or 2 phosphorus atoms. The calcium ions, Ca^{++}, are situated in the holes in the phosphorus-oxygen network and have about 7 oxygen neighbors. In the lime-borate glass, some of the borons are triangularly bonded to 3 oxygens, and the others are tetrahedrally bonded to 4 oxygens.

I. Experimental

X-ray diffraction studies were made on three samples § having the following weight compositions: (1) CaO 0.230, P_2O_5 0.770; (2) CaO 0.283, P_2O_5 0.717; and (3) CaO 0.252, B_2O_3 0.748%.

The three compositions were fused in platinum crucibles, and samples were prepared by drawing fibers from the melt. The weight composition of the 0.717 P_2O_5 glass was calculated from the composition of the calcium metaphosphate, $CaO \cdot P_2O_5$, from which it was made.

The samples used for the X-ray study were rods about 0.5 mm. in diameter. They were placed at the center of an evacuated circular camera, with a radius of 4.45 cm. and were irradiated with MoKα radiation (λ = 0.710 A) made monochromatic by reflection from a rock salt crystal. In order to eliminate the soft fluorescence radiation from the calcium atoms, an aluminum screen was placed in front of the film. The X-ray patterns were microphotometered, and the intensity curves obtained therefrom are shown in Figs. 1 and 2. From a Fourier analysis of the intensity curves, radial distribution curves were obtained for each glass (Figs. 3 and 4).

II. Results

(1) Lime-Phosphate Glasses

Figure 3 shows the radial distribution curves for the lime-phosphate glasses. From X-ray studies of crystalline structures,[1] the phosphorus atom usually is found

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 10, 1940 (Glass Division). Received June 13, 1940.

† Glass Research Fellow. This paper constitutes the sixth report of work done with the assistance of the Glass Research Fellowship sponsored by seven American glass manufacturers.

‡ Research Division, American Optical Co., Southbridge, Mass.

§ The authors are indebted to G. R. Pole of the Tennessee Valley Authority for furnishing analyzed samples of lime-phosphate glasses.

[1] (*a*) J. West, "Quantitative X-Ray Analysis of Structure of Potassium Dihydrogen Phosphate, KH_2PO_4," *Z. Krist.*, **74**, 306 (1930).

(*b*) St. Náray-Szabó, "Structure of Apatite $(CaF)Ca_4(PO_4)_3$," *ibid.*, **75**, 387 (1930).

(*c*) Linus Pauling and J. Sherman, "Crystal Structure of Aluminum Metaphosphate, $Al(PO_3)_3$," *ibid.*, **96**, 481–87 (1937); *Ceram. Abs.*, **19** [5] 126 (1940).

to occur tetrahedrally surrounded by 4 oxygens with a P–O distance of about 1.55 A. The first peak in the distribution curve is at 1.57 A and is interpreted as representing the P–O distance in the glass. The area under this peak corresponds to 4.2 oxygens about each phosphorus atom for both compositions.

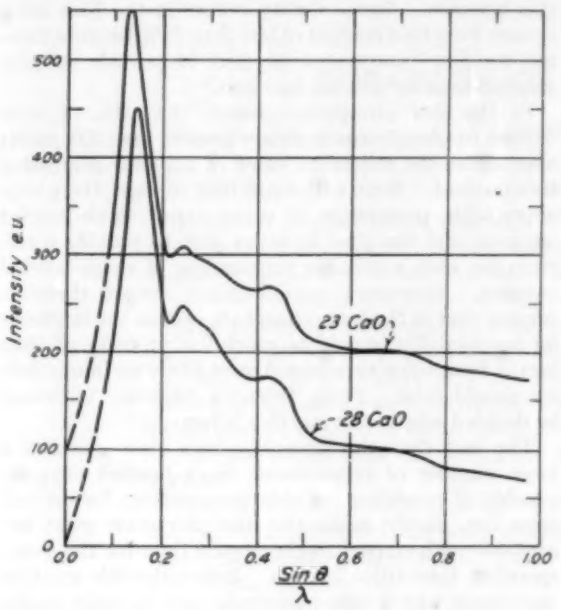

FIG. 1.—X-ray intensity curves for lime-phosphate glass.

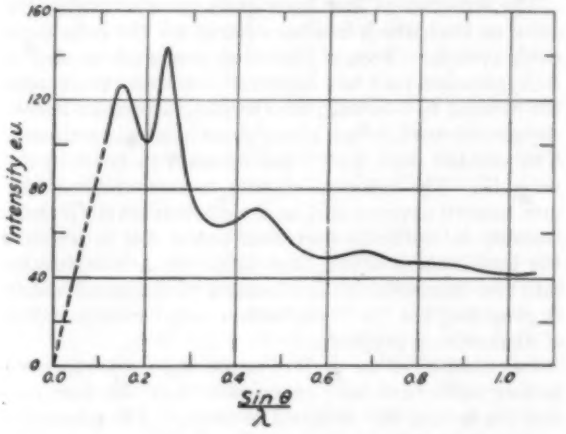

FIG. 2.—X-ray intensity curve for lime-boric oxide glass.

The distance between 2 oxygens, which are part of the same tetrahedral group, should be given by equation (1).

$$\text{O–O} = 1.57\sqrt{\frac{8}{3}} = 2.56\,\text{A}. \qquad (1)$$

From the ionic radii the Ca–O distance should be 2.4 A. The next peak on the distribution curve, occurring at about 2.3 to 2.4 A, therefore is interpreted as the Ca–O and O–O peaks unresolved. If the assumption is made that as many as possible of the oxygens are bonded to two phosphorus atoms and the remainder only to one, the number of oxygens about an oxygen at a distance of 2.56 A can be computed. If the area of the O–O peak is subtracted from the distribution curve, a peak remains at 2.30 to 2.35 A with an area corresponding to about 7 oxygens about a calcium. This is a reasonable value for the number of oxygens surrounding a calcium atom.

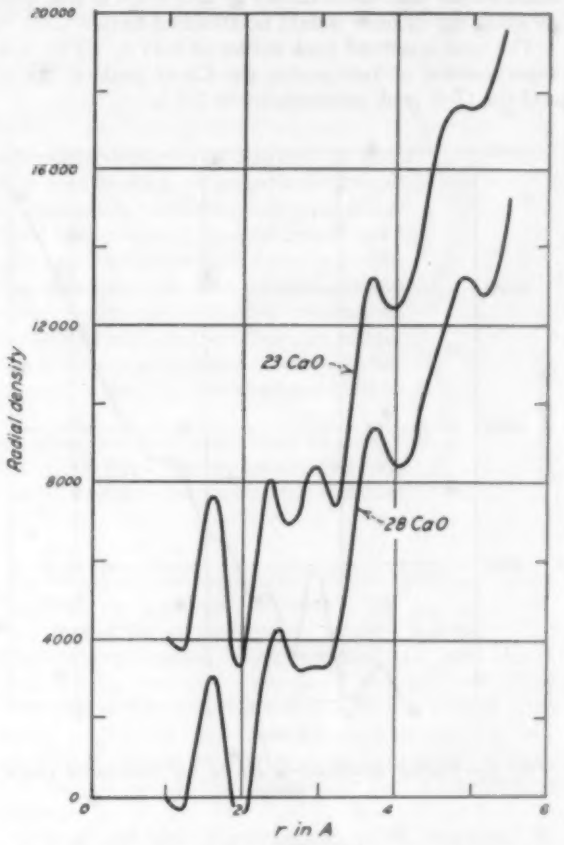

FIG. 3.—Radial distribution curves for lime-phosphate glass.

The next larger distance to be expected is that of phosphorus to phosphorus. If the 2 bonds to an oxygen were diametrically opposite, the P–P distance would be given by equation (2).

$$\text{P–P} = 2\,\text{P–O} = 3.14\,\text{A}. \qquad (2)$$

The peak shows up best on the 23% CaO curve and is seen to be at about 2.94 A. The ratio of 2.94 to 3.14 corresponds to an angle between the 2 oxygen bonds of about 140°.

(2) Lime-Boric Oxide Glass

The radial distribution curve for the one composition studied is shown in Fig. 4. The first peak comes at 1.45 A and represents the boron-oxygen separation. It has been found in other studies that the boron atom is sometimes bonded triangularly to 3 oxygens and some-

times tetrahedrally to 4 oxygens. For triangular coordination, the B–O distance is about 1.39 A; and for tetrahedral bonding, the distance is 1.53 A. Because the center of gravity of the first peak falls between these values, it seems likely that part of the borons are in three-fold and part in four-fold coordination. The measured area under the peak corresponds to 4.3 oxygens about a boron. The scattering power of the boron, however, is so small compared with that of the other atoms that the accuracy of this value is low, and no great significance should be attached to it.

The next observed peak comes at 2.43 A. This is a superposition of two peaks, the Ca–O peak at 2.4 A and the O–O peak at about 2.4 to 2.5 A.

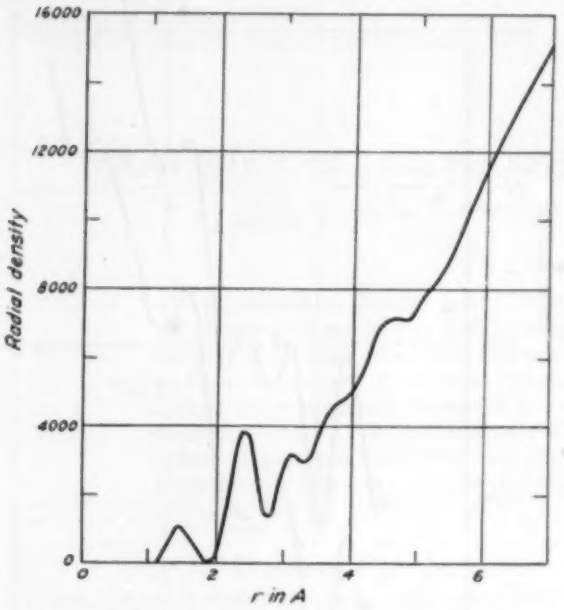

FIG. 4.—Radial distribution curve for lime-boric oxide glass.

III. Discussion

The structure of lime-phosphate glass is roughly the same as that of soda-silica glass.[2] Each phosphorus is tetrahedrally surrounded by 4 oxygen atoms at a distance of about 1.57 A. Part of the oxygens are bonded to 2 phosphorus atoms and part only to 1 phosphorus. The calcium ions, Ca^{++}, situated in holes in the random phosphorus-oxygen network, are so placed as to have an average of about 7 oxygen neighbors. The glass-forming component in this system is the random phosphorus-oxygen network, which plays roughly the same role as the silicon-oxygen network in a silicate glass.

It is instructive to compare the structures of lime-phosphate and lime-silica glass. In the lime-silica glass, the ratio of total oxygen to silicon approaches 2.0 for small lime content. Because each silicon is bonded to 4 oxygens, part of the oxygens are bonded to 2 silicons and part only to 1 silicon. With decreasing lime content, the number of single-bonded oxygens approaches zero. The single-bonded oxygens are unsaturated, and the calcium ions try to surround themselves by a suitable number of such oxygens. The smaller the number of unsaturated oxygens the more difficult this becomes. Immiscibility occurs in the lime–silica system for a lime content of less than 28% because there are too few unsaturated oxygens to provide suitable surroundings for the calcium ions.[3]

In the lime–phosphate system, the ratio of total oxygen to phosphorus is always greater than 2.0, and it approaches the minimum value of 2.5 with decreasing lime content. Even with small lime content, there is an appreciable percentage of unsaturated single-bonded oxygens, and the glass is better able to provide a calcium ion with a suitable surrounding of single-bonded oxygens. Structural considerations would therefore suggest that in the lime–phosphate system the tendency for immiscibility should be much less pronounced than for the lime–silica system and most likely no immiscibility should exist. From Trömel's diagram,[4] it cannot be decided whether or not this is correct.

The fact that the lime-phosphate glass contains a large number of unsaturated single-bonded oxygens, capable of providing suitable surroundings for the calcium ion, should make the lime-phosphate glass less unstable with respect to the crystal than for the corresponding lime–silica system. Indirectly this must be the reason why a lime-phosphate melt is easily cooled to a glass, whereas the lime-silica compositions are much more difficult to retain in the glassy form.

The structure of lime-boric oxide glass is roughly the same as that which has been found for the soda–boric oxide system.[5] Part of the boron atoms are bonded to 3 oxygens and part to 4 oxygens. Most of the oxygens are bonded to 2 borons, thus forming a random boron-oxygen network, which is the glassforming constituent. The calcium ions, Ca^{++}, are situated in holes in the network. The calcium ion tries to surround itself by unsaturated oxygens and, as the calcium ion is divalent, stability is markedly decreased unless this is possible. For lime content of less than 23%, the melt segregates into two immiscible phases because of the impossibility of providing the Ca^{++} ion with a suitable surrounding of unsaturated oxygens.

Calculations of the limit of immiscibility[3] are in satisfactory agreement with experiment if at this composition the borons are assumed to be partly in triangular and partly in tetrahedral coordination.

Lime glasses, such as lime-silica or lime-boric oxide, in general, should have more restricted glassforming properties than the corresponding soda glasses. This is because the calcium ion is divalent and the energy

[2] B. E. Warren and J. Biscoe, "Fourier Analysis of X-Ray Patterns of Soda-Silica Glass," *Jour. Amer. Ceram. Soc.*, **21** [7] 259–65 (1938).

[3] B. E. Warren and A. G. Pincus, "Atomic Consideration of Immiscibility in Glass Systems," *ibid.*, **23** [10] 301–304 (1940).

[4] G. Trömel, "Equilibrium Diagram, CaO-P_2O_5," *Mitt. Kaiser-Wilhelm Inst. Eisenforsch. Düsseldorf*, **14**, 25 (1932).

[5] J. Biscoe and B. E. Warren, "X-Ray Diffraction Study of Soda-Boric Oxide Glass," *Jour. Amer. Ceram. Soc.*, **21** [8] 287–93 (1938).

associated with the Ca^{++} ion and its surrounding oxygens is an important factor. For small lime content, the impossibility of providing suitable surroundings for the calcium ion results in immiscibility. At higher lime content, the calcium ion is not surrounded in the glass in as satisfactory a way as is possible in the orderly structure of a crystal. This energy difference is greater for the divalent Ca^{++} ion than for the monovalent Na^{+} ion, and it is more difficult consequently to cool the lime-glass melt without crystallization setting in.

George Eastman Laboratory of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts

DURABILITY OF OPTICAL GLASS*

By Frank L. Jones†

Abstract

Samples of polished optical glass were exposed under varying conditions, and the optical systems of instruments in use and in storage were studied. Two general types of change in the polished surface were noted in the cases where weathering had taken place. Glass that remained in a humid atmosphere for a long period of time became covered with a hazy film of soluble alkaline salts. All glasses are subject to such dimming in contact with water vapor, but the rate and degree of dimming vary with different glasses. The second type of weathering is the formation of transparent silica-rich surface films because of the loss of high refractive index oxides such as lead or barium from the surface of the glass by solution in water. A filmed glass is usually not harmed in any way, but interference effects make the surface appear colored so that the user considers it to be stained.

A study of durability tests has led to the adoption of a stain test similar to that of Berger. A dimming test has been developed in which glass samples are exposed to a saturated humidity atmosphere for 28 days at 50°C. and then compared with standard ground-glass samples.

I. Introduction

The selection of a laboratory test for glass durability to indicate accurately the ability of the glass to meet service conditions as to resistance to change is difficult even when only a single type of glass is involved. The problem becomes increasingly complicated in the case of optical glass. Types listed in an optical glass catalogue will include borosilicate, soda lime, light barium crown, dense barium crown, barium flint, light flint, dense flint, and others.

In 1937, the Bausch and Lomb Optical Company asked Mellon Institute to study laboratory tests for the durability of optical glass. With the constant addition of new types of glasses as well as the development of existing types to improve their physical and optical characteristics, a need was felt for quicker procedures for determining chemical durability than the outdoor exposure tests. Durability data were also requested by optical manufacturers and other users of domestic optical glass.

II. Types of Weathering

Samples of polished optical glass, exposed under varying conditions, and the optical elements of instruments were studied. Two general kinds of alteration in polished surface were noted, either alone or in combination, on specimens if weathering had occurred. The first type of weathering, called "dimming" by English investigators, is the formation of a hazy film of soluble salts on polished surfaces that are in contact with humid atmospheres but are not in contact with water. All glasses are subject to such dimming if they are kept in a moist atmosphere for a long period of time, but the rate and degree of dimming vary with different glasses.

The second type of weathering, called "staining" by opticians, is the formation of a silica-rich surface layer resulting from the loss of high refractive index oxides, such as lead or barium, from the surface of the glass by their solution in water. The amount of liquid required is so small that fingerprints or condensed moisture may start the action. The presence of an acid, such as dissolved carbon dioxide or the acid in perspiration, greatly speeds the solution. Under normal service conditions, only barium crown and dense flint types are subject to staining. The change is visible when light is reflected from a stained surface because the removal of lead or barium decreases the refractive index of a layer of glass at the surface and the reflectivity of some wave lengths of light is reduced by interference. Ordinarily this film does not damage the polished surface. A lightly stained surface is more transparent than a normal surface. The stain is similar to the treatment purposely applied to some optical systems to increase light transmission. In the past, however, the development of reflected colors on a polished lens has led to complaints,

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 10, 1940 (Glass Division). Received June 13, 1940; revised copy received September 6, 1941.

† Bausch and Lomb Optical Company Industrial Fellowship, Mellon Institute, Pittsburgh, Pa.

so that an effort is made to put high barium or high lead glasses in the inner part of an optical system where they will be protected from solutions.

III. Laboratory Durability Tests

A number of the published methods for determining relative durability were tried out on a series of glass samples to compare laboratory results with the relative resistance to dimming found in actual exposure tests.

Tests proposed to measure the amount of soda or potash leached from the glass did not classify optical-glass types in the order found from exposure. This result is reasonable because a durable borosilicate glass may contain 15% of alkali. Unstable extra dense barium crown glass similarly may be practically free from alkali. The iodeosin method, recommended by Mylius,[1] depends mainly on the formation of insoluble salts of soda and potash; the results, however, were found to be inconsistent with exposure test experience. Solubility tests reported by the bottle industry are not suitable for optical glass for the same reason.[2] By the dimming test developed by Elsden, Roberts, and Jones[3] in England, the sample is exposed in air saturated with water vapor at a temperature of 80°C. for 2 hours. Only hygroscopic glasses, however, are injured by this method. Few modern optical glasses show a visible change in such a short time. The hydrochloric acid vapor test evolved by Weber[4] was found to correlate to some extent with exposure tests, although certain borosilicate glasses did not show up well, notwithstanding their exceptional durability in use.

Because none of the tests mentioned seemed to be adequate for the present study, the writer decided to do additional work on a humidity temperature test. After considerable experimentation, it was found that air saturated with water vapor at 50°C. produced results in 28 days that were comparable with those obtained by exposure in a humid tropical atmosphere on the glasses under consideration.

For the measurement of the tendency to form silica-rich surface layers, the Zschimmer[5] stain test with a solution of 0.5% of acetic acid and 0.5% of glycerol was tried, but the findings were not sufficiently reproducible. The method described by Berger,[6] using a $N/2$ solution of nitric acid at 25°C. as the staining solution, was investigated and gave reproducible results that correlated well with exposure tests. The victoria blue dye test of Hamilton and Finn[7] may be used to indicate the thickness of the silica-rich layer. Berger[8] has employed an interferometer method of measurement in most cases, but he has also used the color of light reflected by the surface as an indication of the thickness of the layer. The latter method was adopted for the present study because of its simplicity.

IV. Dimming Test for Optical Glass

A definite dimming test has been followed in classifying optical glasses. The test conditions were made as similar as possible to the most severe conditions of use. The test period was set at 28 days, which is long enough that even the most durable glasses show some slight haze in a strong light. Comparisons can thus be made between two durable glasses as well as between a good and a poor glass.

The samples of glass, in the form of disks $1/4$ in. thick and 1 in. in diameter, are blocked in paraffin, ground and polished on a pitch lap by rouge, washed in benzene, rinsed in distilled benzene, and wiped on lens paper. After drying overnight, the samples are wrapped in dry lens paper and stored in dry, clean, friction-top tin cans until they are needed. Thus protected from moisture and dirt, samples have been stored for two years with no visible change in properties.

The samples are arranged on edge on a tinned wire rack in a large cylindrical Pyrex-brand glass jar, in the bottom of which, below the level of the wire rack, distilled water is then placed. The top is covered with a brass lid through which a fan projects for circulating the air in the jar. The entire apparatus is put in a thermostatically controlled oven at 50°C. for 28 days, after which time the rack is removed and the samples are air-dried at 50°C. for 2 hours in the oven.

Hygroscopic glasses will be covered with water droplets when they are removed from the jar. Other glasses will not appear damaged, but after they are dried they will show a slight uniformly distributed surface haze if they are examined under a strong light against a black velvet background.

Carefully prepared samples will show the same amount of dimming on each surface, and all samples of the same composition will be equally dimmed. The relative resistance to dimming of two glasses can be judged by direct comparison.

To facilitate the collection of data for this report, four permanent standard samples were made from a durable glass by scratching the surface of polished glass samples. Each polished surface of a 1-in. disk was lightly rubbed with a felt pad moistened with a suspension of fine optical emery (9 μ average diameter). Under a microscope, the standards showed light scratches on a polished surface. The scratches were not apparent to the eye, but the surface scattered light and thus resembled a dimmed glass surface.

---

[1] F. Mylius, "Hydrolytische Klassifikation und Prüfung der Glasarten mit Jodeosin," *Silikat-Z.*, **1**, 2–5, 25–28, 45–48 (1913).

[2] W. C. Taylor and R. D. Smith, "Solubility Characteristics of Glasses Basically Different in Composition," *Jour. Amer. Ceram. Soc.*, **19** [11] 331–35 (1936).

[3] A. V. Elsden, Oswald Roberts, and H. S. Jones, "Examination of Optical Glass in Relation to Weathering Properties," *Jour. Soc. Glass Tech.*, **3**, 52–69 (1919).

[4] R. Weber, "Filming and Opacifying of Glass and Methods for Investigating This Phenomenon," *Dinglers Polytech. Jour.*, **171**, 129 (1864).

[5] E. Zschimmer, "Einige Methoden zur Prüfung der Haltbarkeit von Gläsern für optische Zwecke," *Deut. Mech. Ztg.*, p. 53 (1903).

[6] Jenaer Glas für die Optik. Jenaer Glaswerk Schott & Gen., Catalog 5858g, pp. 3–4, 1938.

[7] E. H. Hamilton and A. N. Finn, "Relative Solubility of Glass as Indicated by Dye Absorption," *Nat. Bur. Stand. Tech. News Bull.*, No. 261, p. 6 (1939).

[8] Edwin Berger, "Fundamental Principles Underlying Chemical Corrosion of Glass," *Jour. Soc. Glass Tech.*, **20** [80] 257–78 (1936); *Ceram. Abs.*, **17** [1] 13 (1938).

(1) Standard Disk Test Results

Standard Disk No. 1: Appeared clear under normal room lighting but showed a slight surface haze when strongly illuminated with a 108-watt microscope lamp against a black velvet background.

Standard Disk No. 2: Showed a slight surface haze just visible under normal room lighting; the percentage of light scattered by the surfaces was less than 1%.

Standard Disk No. 3: Distinctly hazy; the amount of light scattered by the two surfaces was such that the disk transmitted 8% less light than a freshly ground and polished sample when measured in a Martens type of photometer.

Standard Disk No. 4: Showed a heavy surface haze with 20% lower light transmission than a freshly ground and polished sample.

Samples of various types of optical glass were exposed to the dimming test and then classified in comparison with the standard disks by examination against a black velvet background in the light from a 108-watt microscope lamp. *Class 1:* as clear as standard disk No. 1; *class 2:* approximately same amount of surface haze as standard disk No. 2; *class 3:* approximately same amount of surface haze as standard disk No. 3; *class 4:* approximately same amount of surface haze as standard disk No. 4; *class 5:* more surfaze haze than standard disk No. 4 or collected water droplets during test.

TABLE I

DURABILITY TEST RESULTS FOR OPTICAL GLASS

Glass type	Refractive index	*Vd* value	Dimming test class	Stain test class
Borosilicate crown	1.511	63	1	1
	1.516	64	1.5	1
	1.516	64	1	1
	1.517	64	1	1
	1.518	64	1.5	1
Crown	1.523	59	1.5	1
	1.512	60	1.5	1
Light barium crown	1.572	57	2	3
	1.572	57	2	4
	1.573	57	1.5	3
	1.574	58	1	1
Dense barium crown	1.608	59	3.5	5
	1.609	59	3	5
	1.611	59	3	5
	1.611	60	3	5
	1.610	57	1	4.5
	1.611	57	2	5
	1.611	59	3	5
	1.612	57	2	5
Crown flint	1.526	51	3	1
	1.528	52	1	1
	1.528	52	1	1
	1.529	52	1	1
Barium flint	1.581	46	1.5	3
	1.583	47	1	1
	1.584	46	1	1
	1.588	46	2	2.5
	1.605	44	2	2
Extra dense flint	1.717	29	3	3
	1.717	29	2	3.5
	1.720	29	1.5	3
	1.721	29	2	5
	1.648	34	3	2
	1.649	34	2	2
	1.650	34	2	2
	1.650	34	2	2

V. Stain Test for Optical Glass

The stain test is based on that used by Berger.[8] A sample of glass is ground, polished, and cleaned in the manner described for the dimming test. It is immersed in a nitric acid solution ($N/2$) at 25°C., and the time is noted at which light reflected from the surface is a dark blue color. The sample is observed without removing it from the solution, inasmuch as the color change is more easily detected under water. A daylight bulb behind a ground-glass screen is placed in such a position that the image of the light is reflected from the surface of the sample to the eye of the observer. The container in which the samples are immersed is lined with black cloth and tipped at a slight angle so that no stray reflections from the tray or from the surface of the water can interfere with the observations.

The glass is classified according to the number of hours required for the blue interference layer to form as follows: *class 1*, more than 100 hr.; *class 2*, 10 to 100 hr.; *class 3*, 1 to 10 hr.; *class 4*, 0.1 to 1 hr.; and *class 5*, less than 0.1 hr.

VI. Test Results for Various Types of Optical Glass

The resistance to staining and dimming of some common types of optical glass is compared in Table I.

Domestic optical glass compares well in durability with the foreign product. Practically all of the optical glasses of American manufacture have been tested for stain resistance and dimming. The following summary shows comparative test results for some widely used glass types made in the United States and also in Europe.

TABLE II

COMPARATIVE DATA ON AMERICAN AND FOREIGN OPTICAL GLASSES

Samples: (1) American; (2) imported A; (3) imported B; (4) imported C

	Dimming test				Stain test			
Glass type	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Borosilicate crown	1	1	1.5	1.5	1	1	1	1
Light barium crown	2	2	1.5	1	3	4	3	1
Dense " "	3	3	3.5	3	5	5	5	5
Barium flint	1	1	1.5	2	1	1	3	2.5
Dense "	2	4			1	1.5		
Crown "	1	3	1	1	1	1	1	1
Extra dense flint	2	3	2	2	2	2	2	2
" " "	1.5	2	2	3	3	3.5	5	3

The fact that the optical constants are not identical for the glasses of a given type from the several sources renders these data unutilizable for close comparisons.

VII. Relation Between Laboratory and Exposure Tests

The relation between laboratory and exposure test results depends of course on the conditions encountered during exposure. The exposure test specimens commonly show both dimming and staining. Contact with water as a liquid favors stain formation and contact with water as vapor favors dimming.

Specifically, exposure of a series of glasses for nine weeks on a roof in Philadelphia during the winter of 1937 did not produce noticeable change in a borosilicate

glass, but it caused a slight staining of a light barium crown glass and a dense flint glass.

Unprotected exposure for eight weeks on the roof of Mellon Institute in Pittsburgh from September to November, 1937, produced easily noticeable stains on samples that were in classes 3 to 5 in the laboratory test and very slight brown stains on those in class 2, but it did not affect those in class 1. The only glass that was plainly dimmed was a type that rates class 3 in the laboratory test.

Exposure to the high humidity of Rio de Janeiro for six months in an open tray in a business office gave rise to dimming of every sample of both domestic and foreign optical glass. The borosilicate glasses were least affected, and the dense barium crown and the extra dense flint types were clouded and hazy. The samples classed from 3 to 5 by the laboratory test were stained by this South American exposure.

All of the exposure and laboratory tests are more severe than any optical instrument might be expected to receive in normal service. No cases have been found during this study in which staining of an optical glass in use has caused any damage to the surface or to the optical performance of the instrument. The dimming of glass surfaces is not ordinarily noticed except in instruments used in tropical climates; in such climates, microscopes are regularly stored in closed containers with desiccating materials.

VIII. Durability Test Results

(1) Effect of Method of Polishing Glass

Various types of glass were fine-ground with emery and polished by different methods, such as with rouge against felt, with rouge against wax, and with chromium oxide against wax. Polishing was continued for several minutes after the surface appeared clear. The resulting series of samples was subjected to the outdoor exposure test, the dimming test, and the stain test. No difference was found in the stability of a well-polished glass surface made by any of these procedures.

Samples polished only until the surface appeared clear and then immediately removed were seen to acquire a pattern of fine lines when they were subjected to the dimming test or to the stain test. The method of polishing is not important as long as the operation is carried out with a polishing preparation free from particles that will scratch, and the polishing is continued for a sufficient length of time after the grinding scratches are no longer visible.

(2) Effect of Method of Washing Samples

If durability test samples are washed in a clean organic solvent, the results are reproducible, and the entire surface of each test piece is even and uniform. If the samples are washed in water containing detergents or are not completely cleaned, the test results are not dependable. A rough history of a piece of glass can be sketched from the fingerprints, water spots, and tray marks that become visible when a much-handled specimen is tested.

IX. Usefulness of Durability Tests

The two laboratory tests described in this paper have been used to indicate the effect of plant processing on optical glass durability. These tests have been employed in defining the proper glasses for instruments for specific purposes. Laboratory comparisons of the stain resistance and dimming rate of experimental glass melts have demonstrated to a valuable extent the effects of compositional changes on durability. Slight modifications in composition in some instances have led to measurable improvements in durability.

Mellon Institute
Pittsburgh, Pennsylvania

EFFECT OF COMPOSITION AND THERMAL HISTORY ON DIELECTRIC CONSTANTS OF SODA-BOROSILICATE GLASSES*

By J. M. Humphrys and W. R. Morgan

Abstract

The dielectric constants, densities, and refractive indices of two series of soda-borosilicate glasses were measured at 25°C. on some quenched specimens and on other specimens that were stabilized at different temperatures. The compositions of the two series were $Na_2O \cdot 4.69SiO_2$–B_2O_3 (0 to 45%) and $Na_2O \cdot B_2O_3$–SiO_2 (30 to 100%), respectively. The structure of the glasses was found to depend on the ratio of oxygen atoms to the sum of the boron and silicon atoms and also on the concentration of the sodium ions. If the ratio of O to B + Si is greater than 2.0 or if the ratio of oxygen to sodium ions is less than 6.0, some of the oxygens are bonded only to one boron or to one silicon atom. The presence of "single-bonded" oxygen atoms in the glass structure leads to a lower density and a higher dielectric constant and refractive index. The dielectric constant decreases and the density increases continuously as the temperature of heat treatment is lowered. The effect of heat treatment is greater for the glasses which contain the larger number of "single-bonded" oxygen atoms and the higher concentration of sodium ions.

I. Introduction

In view of the value of dielectric studies in the investigation of the molecular structure of gases, liquids, and solutions and because of the scarcity of data on the relation between dielectric constant and composition for glasses, the dielectric constants of a number of simple glasses were investigated. The purpose of this study was to determine the effect of composition and heat treatment on the dielectric constants of glasses of the system Na_2O–B_2O_3–SiO_2.

(1) Historical

Investigations that were made before 1932 have been collected and discussed by Littleton and Morey,[1] and their review emphasizes the scarcity of data on the relation between dielectric constant and composition. Hopkinson[2] showed that with the ordinary crown-flint series of glasses the dielectric constant varied linearly with the density, the ratio of the dielectric constant to the density being approximately 2.2.

The work of Rubens,[3] Jäger,[4] Addenbrooke,[5] Schott,[6] and MacLeod[7] showed that the change in dielectric constant with frequency in the radio band is very small; for example, the maximum change observed by Schott was a decrease of about 1/2% as the frequency increased from 1.9×10^6 to 10^8 cycles.

Strutt,[8] who studied the effect of temperature on the dielectric constant at different frequencies, found that the higher the frequency the less the dielectric constant depends on temperature. The only investigation of the temperature dependence of the dielectric constant in the softening interval was made by Tammann and Boehme,[9] who state that the dielectric constant increases slowly from room temperature to the transformation region, whereupon a rapid increase occurs with further rise in temperature.

Since the review of Littleton and Morey, two systematic studies of the effect of composition on the dielectric constant have appeared, one by Keller[10] and the other by Egami.[11] They found that, in general, the acidic oxides decrease the dielectric constant and the basic oxides increase it. Keller arranged a number of oxides in decreasing order of their ability to raise the dielectric constant when substituted for silica in a glass with a composition of 18% of soda and 82% of silica. The series is as follows: Na_2O, K_2O, CaO, BaO, PbO, MgO, ZnO, B_2O_3, Al_2O_3, and Fe_2O_3.

---

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 10, 1940 (Glass Division). Received July 15, 1940.

This paper is based on data obtained by the senior author in preparation of a thesis which has been accepted by Rutgers University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

The study was made possible by the granting of a fellowship to the senior author by the Edward Orton, Jr., Ceramic Foundation, Columbus, Ohio.

[1] J. T. Littleton and G. W. Morey, Electrical Properties of Glass. John Wiley & Sons, New York, 1933; *Ceram. Abs.*, **12** [12] 419 (1933).

[2] J. Hopkinson, *Trans. Roy. Soc.* [London], **1**, 17 (1878); *ibid.*, **2**, 355 (1881); cited by Littleton and Morey, *loc. cit.*, p. 106.

[3] H. Rubens, "Reflective Power and Dielectric Constants of Nonconducting Solids and Some Liquids," *Sitzber. kgl. preuss. Akad. Wiss.*, II, p. 1280 (1915).

[4] R. Jäger, "Dielectric Constants of Solids," *Ann. Physik*, [4] **53**, 409–60 (1918).

[5] G. L. Addenbrooke, "Electrical Properties of Flint Glass of Density 6.01," *Phil. Mag.*, **45**, 516–25 (1923); *Ceram. Abs.*, **2** [9] 195 (1923).

[6] E. Schott, "High-Frequency Loss in Glass and Several Other Dielectrics," Phil. Diss., Jena, 1923.

[7] H. J. MacLeod, "Variation with Frequency of Power Loss in Dielectrics," *Phys. Rev.*, **21**, 53–73 (1923).

[8] M. J. O. Strutt, "Dielectric Properties of Different Glasses in Relation to Frequency and Temperature," *Arch. Elektrotech.*, **25**, 715 (1931); *Ceram. Abs.*, **12** [4] 145 (1933).

[9] G. Tammann and W. Boehme, "Temperature Dependence of Dielectric Constant of Some Glasses in the Softening Range," *Z. anorg. allgem. Chem.*, **197** [1] 1–17 (1931); *Ceram. Abs.*, **10** [9] 629 (1931).

[10] F. Keller, "Dielectric Constants of Glasses of Different Composition," *Z. tech. Physik*, **13** [5] 237–39 (1932); *Ceram. Abs.*, **11** [8] 448 (1932).

[11] K. Egami, "Relation Between Chemical Composition and Dielectric Loss for Glasses R_2O-CaO-SiO_2, R_2O-B_2O_3-SiO_2, and R_2O-PbO-SiO_2," *Jour. Japan. Ceram. Assn.*, **42**, 619–28 (1934); *Ceram. Abs.*, **18** [4] 98 (1939).

McDowell and Begeman[12] showed that a strained glass has a higher power factor and a higher dielectric constant than an annealed glass. More recent work by Funk[13] has shown that the dielectric constant is particularly sensitive to the influence of thermal history. The dielectric constant of quenched sodium disilicate glass, for example, was 9.56, and it was 9.00 when it was heated at 600°C. and cooled slowly in the furnace.

(2) Dielectric Theory

When the polar and nonpolar molecules are placed in an electric field, they become polarized by induction. A molecule may be regarded as an elastic body which, under the influence of an electrical force, will suffer two simultaneous deformations, that is, the electrons and the nuclei will be displaced from their mean positions. These displacements correspond to induced moments, m_E and m_A, respectively. When a molecule possessing a permanent dipole is placed in an electric field, it will tend to align its moment against the field. The orientative action of the field is hindered by thermal agitation which tends to produce an equal orientation in all directions. The slight excess of dipoles directed against the field corresponds effectively to a further moment, m_O. The total average moment exhibited by a molecule in an electrostatic field is given in equation (1).

$$m = m_E + m_A + m_O = (c_E + c_A + c_O)F. \quad (1)$$

Where c = moment for a unit field.
F = field intensity.

The Mosotti-Clausius equation relates the total average moment to the dielectric constant, K, as follows:

$$\frac{K-1}{K+2} \cdot \frac{M}{d} = \frac{4\pi N}{3}(c_E + c_A + c_O). \quad (2)$$

Where M = molecular weight of substance.
d = density.
N = Avogadro number.

The quantity on the left-hand side of equation (2) is called the total molecular polarization, P, which is equal to the sum of three terms, the electronic, atomic, and orientation polarizations, P_E, P_A, and P_O, respectively. P_E is identical with the molecular refraction given by the Lorenzt-Lorenz equation,

$$P_E = \frac{n^2-1}{n^2+2} \cdot \frac{M}{d}. \quad (3)$$

There is no way of evaluating P_A theoretically. For most organic molecules, P_A is small; for substances, however, made up of ions or containing highly polar linkages, it may amount to a large fraction of the total polarization. P_O will be zero if the molecules either have no permanent dipole moment or the molecular dipoles are unable to orient in an externally applied field.

The SiO_4 tetrahedron and the BO_3 plane triangle should be nonpolar according to classical stereochemistry and therefore should show no orientation polarization. The usual criterion of nonpolarity is that the dielectric constant, measured at audio or radio frequencies, be roughly equal to the square of the refractive index observed with visible light at the same temperature. The following comparison is made for vitreous SiO_2 and B_2O_3:

	K	n^2_D
SiO_2	3.82	2.13
B_2O_3	3.50	2.12

The bond directions of the Si–O tetrahedra and B–O triangles apparently are distorted in the random network so that some polarity results. In order that P_O be zero, the orientation of the dipoles under the influence of the measuring field is impossible. As glass at ordinary temperatures has such an enormous viscosity, it might be concluded that the orientation of dipoles would be prohibited. It is considered probable, however, that viscous forces are not the only ones affecting dipole orientation.[14] This means that molecules are capable of two kinds of motion, namely (*a*) elastic displacement and (*b*) a change of position, that is, viscous flow. Which motion occurs depends on the frequency, and with increasing frequency, it will tend more and more toward the elastic displacement. Owing to the fact that the change of frequency has but little effect on the dielectric constant of glass, especially in the radio frequency band, and that glass is nonmolecular by nature, it may be concluded that P_O is zero and that all of the polarization is caused by displacements of electrons and atoms.

From equations (2) and (3), the specific polarizations per gram become

$$p = \frac{K-1}{K+2} \cdot \frac{1}{d} = p_E + p_A. \quad (4)$$

$$p_E = \frac{n^2-1}{n^2+2} \cdot \frac{1}{d}. \quad (5)$$

$$p_A = p - p_E = \frac{3(K-n^2)}{(K+2)(n^2+2)} \cdot \frac{1}{d}. \quad (6)$$

II. Experimental

(1) Specimens

The glasses were prepared by melting reagent quality silicic acid, sodium carbonate, sodium borate, and boric acid in platinum. Each batch was melted three times with intermediate grinding and sieving to insure homogeneity. Two series of nine glasses each were obtained by blending analyzed end members. The compositions, which were obtained by careful synthesis, agreed excellently with values obtained by analysis. The

[12] (*a*) L. S. McDowell and Hilda Begeman, "Behavior of Glass as a Dielectric in Alternating Current Circuits: I, Relation of Power Factor and Dielectric Constant to Conductivity," *Phys. Rev.*, **31**, 476–81 (1928); *Ceram. Abs.*, **7** [8] 533 (1928); (*b*) "II, Effect of Frequency and Temperature on Power Loss," *Phys. Rev.*, **33**, 55–65 (1929).

[13] H. J. Funk, "Investigation of Dielectric Constants of B_2O_3- and TiO_2-Containing Sodium Disilicate Glasses." Dissertation, Berlin, 1937; made available through the courtesy of W. Weyl.

[14] A. Gemant, "Conception of a Complex Viscosity and Its Application to Dielectrics," *Trans. Faraday Soc.*, **31** [11] 1582–90 (1935); *Ceram. Abs.*, **15** [4] 117 (1936).

specimens were prepared in the form of rods by drawing from the molten glass with a stiff platinum wire. When severely quenched specimens were needed, the melt was quenched in mercury, broken into coarse fragments, and screened to remove particles finer than 8-mesh. The analyses of the glasses are given in Table I.

TABLE I
COMPOSITIONS OF GLASSES STUDIED

Glass	No.	Na_2O (wt. %)	B_2O_3 (wt. %)	SiO_2 (wt. %)
A	1	18.05		81.95
	2	17.14	5.03	77.83
	3	16.25	10.00	73.75
	4	15.34	15.02	69.64
	5	14.49	19.74	65.77
	6	13.54	25.00	61.46
	7	12.65	29.98	57.37
	8	11.75	34.92	53.33
	9	9.94	44.99	45.07
B	1	32.77	37.40	29.83
	2	30.12	34.50	35.38
	3	27.53	31.66	40.81
	4	24.93	28.80	46.27
	5	22.20	25.82	51.98
	6	19.58	22.94	57.48
	7	16.91	20.02	63.07
	8	14.41	17.27	68.32
	9	9.01	11.35	79.64

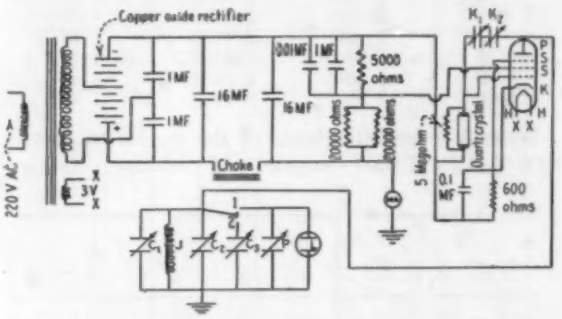

FIG. 1.—Wiring diagram of dielectric constant apparatus. Vacuum tube: *P*, plate; *S,S*, suppressor; *K*, cathode; *H*, heating elements; *X,X*, connections to transformer; K_1,K_2, variable air condensers.

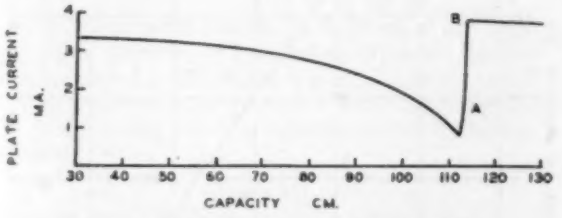

FIG. 2.—Effect of capacity in anode circuit.

(2) Apparatus

The apparatus used to measure the dielectric constants consists essentially of a high-frequency oscillating circuit in which a quartz crystal is inserted to maintain a fixed frequency of 1525.1 kc. The wiring diagram of the circuit is shown in Fig. 1. If the capacity in the anode circuit is increased, the plate current will fall, at first very slowly and then more rapidly, until it reaches a minimum; a further increase in capacity causes the plate current to increase quickly (Fig. 2). On adjusting the milliammeter, which is placed in the anode circuit to some point between *A* and *B*, the capacity may be fixed sharply.

If, therefore, two condensers are inserted in parallel in the circuit, one as a receptacle for the material being investigated (*L*, Fig. 3), the other for keeping the total capacity constant (precision condenser, *P*), it will always be possible to adjust the anode current to the same value. The increase in capacity of the measuring cell is equal to the decrease in capacity of the precision condenser and vice versa.

Fluctuation in the alternating-current supply is detected by a fluctuation in the milliammeter reading when the condenser, C_3, is switched in; this is compensated by means of the variable condenser, C_2, which has a small capacity. The condensers, C_1 and C_3, which are used to adjust the current to the region of greatest sensitivity, remain fixed throughout the course of a measurement. The precision condenser, *P*, is a hollow screw with a micrometer scale attached; one scale division corresponds to a capacity of 0.001 cm., and the total capacity is 5 cm.

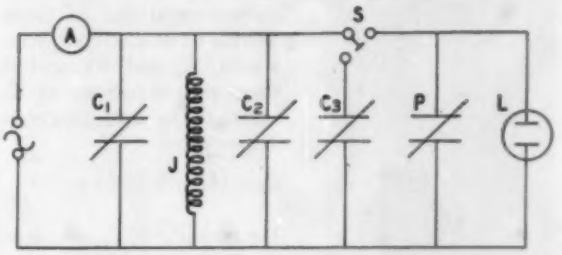

FIG. 3.—Diagram of apparatus.

The measuring cell (Fig. 4), which has a capacity of 0.38 cm. and a volume of about 5 cc., consists of two glass tubes concentrically adjusted, leaving open an annular space with inlet and outlet channels. The inner tube is platinized on the outside and the outer tube on the inside. The two thin platinum layers form the coatings of the condenser; the distance between them is about 5 mm. The condenser has a removable plug in its base, *A*, held in place by metal springs, *BB*. The glass sample is introduced through this opening; the comparison liquids are poured in at *C*, keeping *D* closed; and they are removed by blowing in dry air at *E*, keeping *C* closed.

The density determinations were made by a flotation method, using bromoform and pentachloroethane as the suspending liquids. The refractive-index measurements were made by the microscopic immersion method, using sodium D light.

III. Measurement of Dielectric Constant

The dielectric constant was measured by the mixture method first described by Starke.[15] The air between

[15] H. Starke, "Über eine Methode zur Bestimmung der Dielectrikitätskonstanten fester Korper," *Wied. Ann.*, **60**, 629–41 (1897); *ibid.*, **61**, 804–805 (1897).

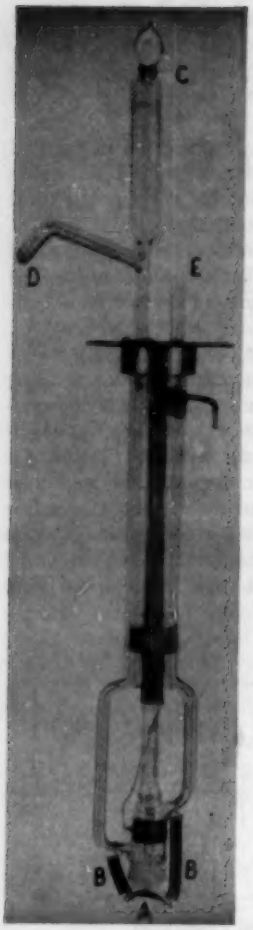

FIG. 4.—Measuring condenser.

the solid particles is displaced by organic liquids in which the glass is inert. The liquids used, which were mixtures of toluene, chlorobenzene, and orthonitrotoluene, were chosen because they cover the range of dielectric constants expected for the glasses and they also have low conductivities (10^{-13} to 10^{-8} ohm^{-1} per cm.$^{-1}$).

The dielectric constant is defined by $K = C/C_0$, in which C is the capacity of a condenser filled with the substance under investigation and C_0 is the capacity of the same condenser when it is empty. To obtain C_0, the difference is measured in the capacity of the cell when it is filled with liquids of known difference in dielectric constant. If these liquids have dielectric constants, K_1 and K_2, and if they give capacities of C_1 and C_2 to the measuring condenser, then

$$C_0 = (C_1 - C_2)/(K_1 - K_2). \quad (7)$$

Because $C_1 - C_2$ is measured on the precision condenser and $K_1 - K_2$ is known, C_0 may be calculated.

To evaluate K_x for a liquid of unknown dielectric constant, the difference in capacity between the unknown and a known liquid is determined. Then equation (8) may be calculated by using the value of C_0 already found.

$$K_x = \frac{(C_x - C_2)}{C_0} \cdot K_2. \quad (8)$$

Where subscript 2 refers to the known liquid.

To determine the dielectric constant of a glass, the difference in capacity is determined between the measuring cell filled with liquid plus glass and the cell filled only with liquid. This difference is determined for three or more comparison liquids and is plotted against the dielectric constant of the comparison liquid (Fig. 5). The point at which the resulting straight line intersects the K axis ($\Delta C = 0$) corresponds to a liquid, the capacity of which is unaltered by the introduction of the glass. The intercept is taken as the dielectric constant of the glass.[16]

[16] J. Errera and H. Ketelaar, "Relations Between Optical and Dielectric Properties; Ionic Polarization in Solids," *Jour. Phys. Radium*, [7] **3**, 239–47 (1932).

IV. Data Obtained

(1) Effect of Composition

The dielectric constants, densities, and refractive indices, measured at 25°C. for glasses stabilized at 450°, are given in Table II. When a glass could not be stabilized at 450°, the values were taken for the lowest temperature at which it could be stabilized during the period of one week.

TABLE II

DIELECTRIC CONSTANTS, DENSITIES, AND REFRACTIVE INDICES OF GLASSES STABILIZED AT 450°C. AND MEASURED AT 25°C.

Glass No.	Dielectric constant	Density	Refractive index
A1	6.20	2.3651	1.491
2	6.39	2.4150	1.500
3	6.42	2.4537	1.508
4	6.46	2.4697	1.510
5	6.41	2.4645	1.513
6	6.15	2.4187	1.508
7	5.77	2.3693	1.505
8	5.35	2.3083	1.499
9	4.61	2.2039	1.489
B1	8.10	2.5120	1.525
2	7.82	2.5337	1.527
3	7.55	2.5408	1.528
4	7.34	2.5382	1.523
5	7.12	2.5333	1.521
6	6.88	2.5209	1.519
7	6.62	2.4945	1.517
8	6.36	2.4622	1.512
9	5.46	2.3775	1.497
SiO_2	3.82	2.1977	1.459

Series A represents glasses of the system $Na_2O \cdot 4.69 SiO_2$–B_2O_3, and their densities and dielectric constants

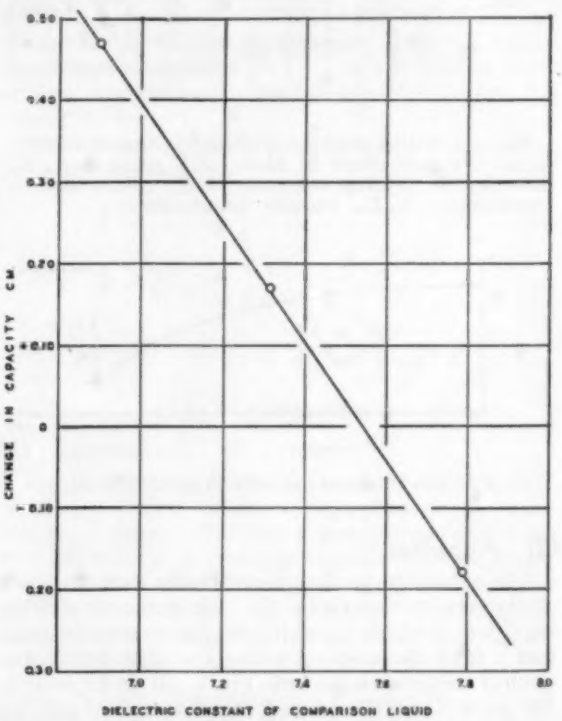

FIG. 5.—Method of evaluation.

are plotted against the weight percentage of B_2O_3 added to the base glass, A1 (see Figs. 6 and 7). These figures also show the ratio of the total number of oxygen atoms to the sum of the numbers of boron and silicon atoms for each 10% of B_2O_3 added.

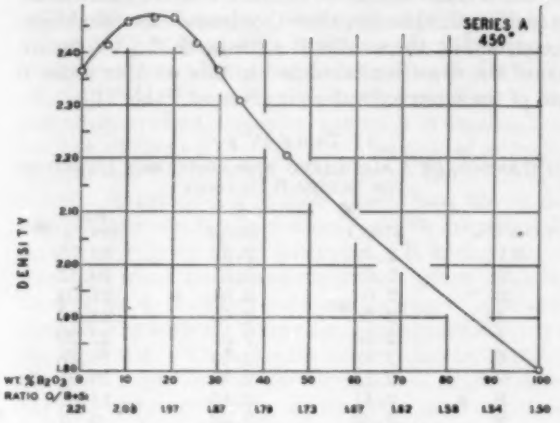

FIG. 6.—Densities of series A glasses.

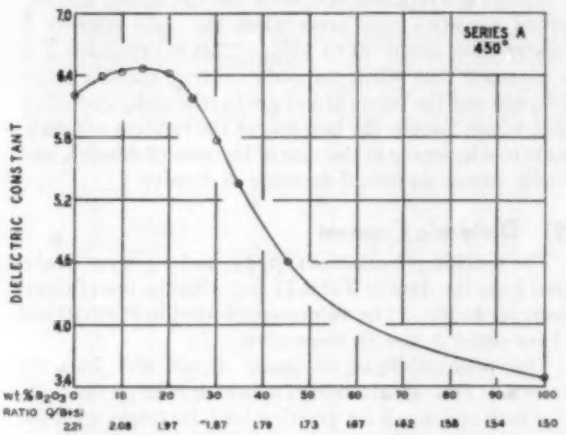

FIG. 7.—Dielectric constants of series A glasses.

Series B represents glasses of the system $Na_2O \cdot B_2O_3$–SiO_2. The densities and dielectric constants for this series are shown in Figs. 8 and 9, plotted against the mol fraction $Na_2O \cdot B_2O_3$. The ratio of total oxygen to the sum of boron and silicon is constant at 2.0 throughout this series.

TABLE III

EFFECT OF HEAT TREATMENT ON DIELECTRIC CONSTANT
(Decrease in dielectric constant for a 1% increase in density)

Glass No.	Decrease in K (%)	Glass No.	Decrease in K (%)
A 1	4.6	B 1	5.6
2	4.3	2	5.2
3	3.2	3	5.0
4	1.8	4	4.6
5	1.5	5	4.0
6	3.2	6	3.6
7	3.7	7	2.9
8	3.8	8	2.0
9	3.8	9	1.8

(2) Effect of Heat Treatment

Each of the glasses was stabilized at a number of temperatures. The glass was quenched in air after each stabilization, and the dielectric constant and density were measured at 25°C. There is, in general, a continuous decrease in the dielectric constant and a continuous increase in the density as the temperature of stabilization is lowered. Table III shows the percentage decrease in dielectric constant for an increase of 1% in density caused by the heat treatment.

V. Discussion of Results

(1) Density

Biscoe and Warren[17] explain the maximum in the density curve for series A (Fig. 6) to be the result of the ability of boron to exist both in tetrahedral and in triangular coordination. Glass A1, which contains no B_2O_3, has an oxygen-to-silicon ratio of 2.21 and there-

[17] J. Biscoe and B. E. Warren, "X-Ray Diffraction Study of Soda-Boric Oxide Glass," *Jour. Amer. Ceram. Soc.*, 21 [8] 287–93 (1938).

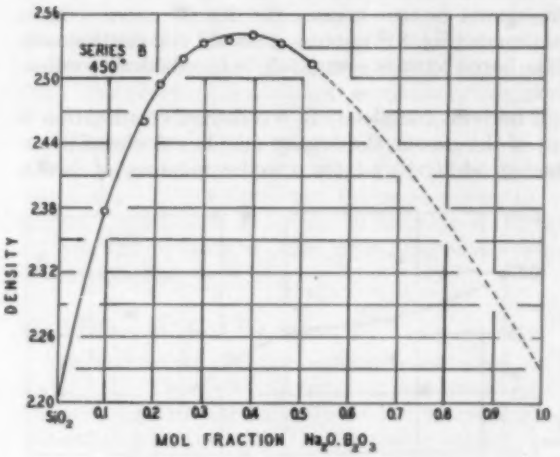

FIG. 8.—Densities of series B glasses.

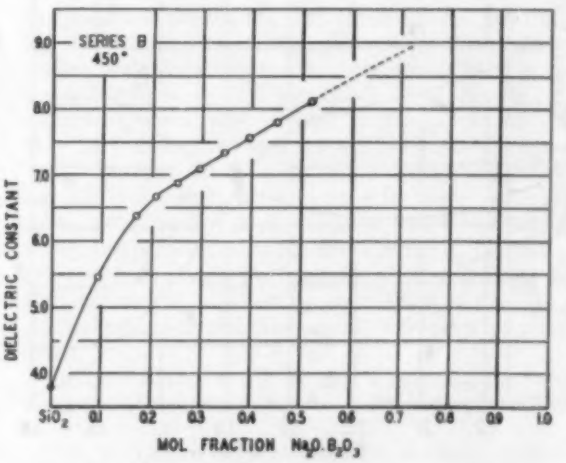

FIG. 9.—Dielectric constants of series B glasses.

fore contains an appreciable number of "single-bonded" oxygen atoms. When B_2O_3 is added, part of the single-bonded oxygen is changed to double-bonded oxygen to allow the added boron atoms to go into tetrahedral coordination. As more B_2O_3 is added, more of the single-bonded oxygen is used up and the density rises owing to the elimination of the breaks in the random network caused by single-bonded oxygens. The density continues to rise until all of the single-bonded oxygen is used up; this occurs when the ratio of oxygen to boron plus silicon is 2.0. When B_2O_3 is added to the glass beyond this amount, it is no longer possible for the boron to change to tetrahedral coordination because no extra oxygen bonds are available. The additional boron atoms remain in triangular coordination; because this involves bonding to the rest of the structure in three directions rather than in four, the structure becomes steadily looser and the density decreases as the ratio of oxygen to boron plus silicon decreases below 2.0.

For series B, the ratio of oxygen to boron plus silicon is constant at 2.0 throughout; both the boron and the silicon atoms, therefore, might always be expected to be in tetrahedral coordination in these glasses. Evidently this cannot be true because the density curve shows a maximum (Fig. 8), whereas it should rise continuously if the boron remains completely in tetrahedral coordination.

If boron is completely in tetrahedral coordination in any of the glasses, the density may be calculated by assuming additivity of the specific volumes of $Na_2O \cdot B_2O_3$ and SiO_2 because all of the glasses of series B may be written as $Na_2O \cdot B_2O_3 \cdot xSiO_2$. Sodium metaborate ($Na_2O \cdot B_2O_3$) has the specific volume of the hypothetical glass, which is derived from vitreous silica by replacing each silicon by a boron atom and by introducing one sodium ion into a network hole for each boron. In making this change, allowance is made for the shrinkage caused by the smaller B–O distance.[17] A comparison of the densities calculated in this way for series B and of the observed values is given in Table IV.

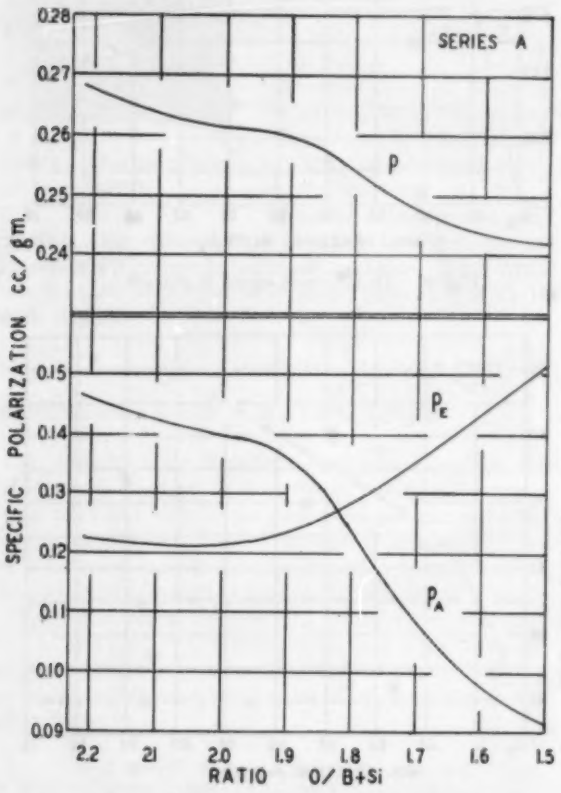

FIG. 10.—Specific polarizations for series A glasses.

TABLE IV

COMPARISON OF CALCULATED AND OBSERVED DENSITIES FOR SERIES B GLASSES

Glass No.	$d_{(calc.)}$	$d_{(obs.)}$	Na_2O (wt. %)
B1	2.73	2.51	32.77
2	2.68	2.53	30.12
3	2.63	2.54	27.53
4	2.58	2.54	24.93
5	2.53	2.53	22.20
6	2.49	2.52	19.58
7	2.45	2.49	16.91
8	2.41	2.46	14.41
9	2.33	2.38	9.01

Serious discrepancies between the calculated and observed densities may arise when the soda content is greater than about 20 to 25%. This is explained if it is assumed that when the soda content exceeds about 20% some of the boron atoms are in triangular coordination, which loosens the bonding of the random network, leads to a lessening in the rate of increase of density, and finally causes an actual decrease of density.

(2) Dielectric Constant

The specific polarizations, p, p_E, and p_A, were evaluated from the data of Table II and with the use of equations (4) to (6). The values are plotted in Figs. 10 and 11 for series A and B, respectively.

The polarizabilities of many atoms and ions are known. The polarizability, α, which is large for negative ions and small for positive ions, increases with the size of the ion. For the O^{--} ion, $\alpha = 2.76$; for Si^{4+}, $\alpha = 0.039$; for B^{3+}, $\alpha = 0.020$; and for Na^{+}, $\alpha = 0.197$. In a borosilicate glass, therefore, the polarization is due largely to oxygen ions.

Two factors that influence p_E are (*a*) the number of oxygens per gram of glass and (*b*) the nature of the bonding of the oxygens. Referring to the data for series A (Fig. 10), the number of oxygens per gram increases as the ratio of O to B + Si decreases; but when the ratio is greater than 2.0, some of the oxygen is single bonded, and the removal of these more polarizable oxygens counteracts the effect of increasing oxygen concentration and leads to the virtual constancy of p_E for the O to B + Si ratios above 2.0. For ratios below 2.0, there is only the effect of increasing oxygen concentration, and p_E increases continuously.

Referring to the data for series B (Fig. 11), the oxygen concentration decreases slowly with the increasing mol fraction of $Na_2O \cdot B_2O_3$, and p_E should decrease slowly. The slow increase in p_E for mol fractions greater than about 0.3 must be due to the increasing proportion of single-bonded oxygen, created by the reversion of some

of the boron atoms from tetrahedral to triangular coordination.

The failure of boron always to assume tetrahedral coordination, even though the necessary oxygen is available, appears to be connected with the sodium-ion concentration. In discussing the structure of soda-boric oxide glasses, Biscoe and Warren[18] state that "beyond about 16% of Na_2O, the tendency for the borons to change over to tetrahedral coordination begins to fall off, and the transition is no longer complete." This failure occurs for the glasses of series B at about 0.2 mol fraction of $Na_2O \cdot B_2O_3$ (Fig. 9). The ratio of oxygen to sodium ions for these two cases, is 5.9 and 6.0, respectively. X-ray studies of these glasses have shown that each sodium ion in the random network is surrounded on the average by about 6 oxygens. It appears, therefore, that when the ratio of oxygen to sodium ions is less than about 6, the extra sodium ions may be accommodated in the network holes only if breaks are created in the structure. These breaks are created by breaking the B–O bonds and by the formation of single-bonded oxygens about which the sodium ions tend to concentrate. In other words, some of the boron atoms are in triangular coordination.

The atomic polarization, p_A, arises from the displacement of atomic nuclei. For such displacements to have a dielectric effect, the atoms must carry a net electric charge, that is, they must be ions or they must form part of polar linkages. All of the linkages present in these glasses are polar because even pure vitreous silica and boric oxide have atomic polarizations amounting to 43.4 and 37.6%, respectively, of the total polarization. As already suggested, this probably arises from the deflection of the bonds in the random network.

A BO_4 tetrahedron consists of a central boron atom bearing three positive charges surrounded by 4 oxygens in which the boron has only a one-half share; the other half share belongs to the boron or silicon of the neighboring tetrahedron. Each oxygen will contribute one negative charge, making four in all, and leaves the BO_4 tetrahedron with a net negative charge of one. This is compensated by one sodium ion, and the glass as a whole is electrically neutral. On the basis of these considerations, the atomic polarization may be expected to increase with increasing sodium-ion concentration and with an increasing number of BO_4 tetrahedra. This is confirmed by the data of Figs. 10 and 11.

Figure 10 shows that, starting with 2.2 as the ratio of O to B + Si, the concentration of sodium ions decreases continuously, whereas the number of BO_4 tetrahedra per gram increases until the ratio of 2.0 is reached and then it decreases continuously. The counteraction of the decreasing Na^+ ion concentration and the increasing number of BO_4 tetrahedra accounts for the slower rate of change of p_A for O to B + Si ratios above 2.0. The two factors act together for ratios below 2.0.

In series B (Fig. 11), p_A increases rapidly with increasing mol fraction of $Na_2O \cdot B_2O_3$ because of the increasing concentration of the Na^+ ions and the BO_4 tetrahedra. When the boron begins to revert to triangular coordination, the rate of increase of p_A falls off, presumably because of the decreasing proportion of BO_4 tetrahedra.

[18] *Loc. cit.*, p. 290.

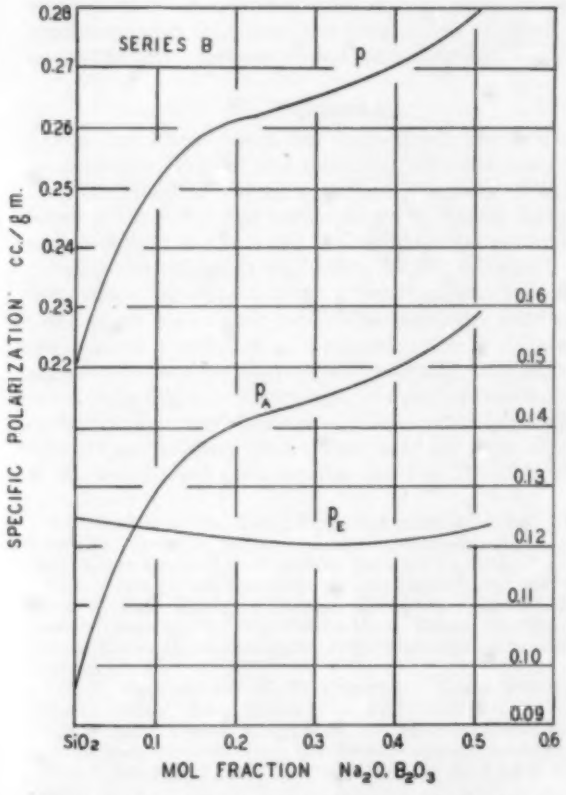

FIG. 11.—Specific polarizations for series B glasses.

(3) Effect of Heat Treatment

The data on the effect of heat treatment are given in Table III. The dielectric constant decreases and the density increases continuously as the temperature of stabilization is lowered. The increasing density tends to increase the dielectric constant, but this effect is more than compensated for by the opposite effect of structural changes so that the net result is a decrease in the dielectric constant. The effect of heat treatment on the dielectric constant is greatest for the glasses of highest soda content, that is, those which have single-bonded oxygens in their structure. The effect of heat treatment, conversely, is least for the glasses with an O to B + Si ratio of near 2.0 and a low soda content.

The concept of "association" in polar liquids is a familiar one, and it has been used by many writers to explain the changes in physical properties which occur when glass is cooled from the fluid condition. Although this concept explains the behavior of glass in a qualitative manner, no satisfactory description of the "associating" groups or of the degree of "association" has been given.

Taylor[19] has been able to give a quantitative interpretation of the rate of release of strain in glass by as-

[19] N. W. Taylor, "Law of Annealing of Glass: Quantitative Treatment and Molecular Interpretation," *Jour. Amer. Ceram. Soc.*, **21** [3] 85–89 (1938).

suming that two independent processes occur during annealing, namely, a first-order process consisting of de-orientation or depolarization of the dissociated units assumed to be present in a quenched glass, and a second-order process consisting of the interaction between two dissociated units.

Mueller[20] has shown that the photoelastic effect in glass is caused by elastic deformation which (*a*) changes the arrangement of the atoms and alters the Lorenz-Lorentz interaction between the dipoles and (*b*) produces optical anisotropy by deformation of the atoms. A uniform volume expansion of 1% increases the refraction of an oxygen ion by 0.4%. The oxygen ions in a quenched glass therefore have a greater polarizability than in an annealed glass. A decrease of 0.4% in the total polarization causes a decrease of 1.4% in the dielectric constant when K equals 10 and a decrease of 0.6% when K equals 4.

The dielectric constant of a glass, on the basis of the foregoing views, will be expected to decrease with decreasing temperature of stabilization for three reasons, namely, (1) the polarizability of the oxygen ion decreases as the strain decreases and the strength of bonding increases; (2) a de-orientation of the small clusters of Si–O and B–O tetrahedra and of B–O triangles leads to the compensation of dipoles; and (3) a growth of the size of the clusters of tetrahedra and triangles, results in smaller interatomic distances and larger binding forces which in turn decrease the polarizability of the structure. The effect of (1) is common to all the glasses, but it is less for the glasses with lower dielectric constant. The magnitude of the effects in (2) and (3) varies with the composition, being greater for the glasses containing the greater numbers of free ions and single-bonded oxygens.

[20] Hans Mueller, "Theory of Photoelasticity," *Jour. Amer. Ceram. Soc.*, **21** [1] 27–33 (1938).

VI. Summary

In the two series of simple soda-borosilicate glasses which were studied, it was found that if the ratio of oxygen atoms to the sum of the boron and silicon atoms is greater than 2.0 or if the ratio of oxygen to sodium is less than 6.0, some of the oxygens are bonded only to one boron or to one silicon atom. The presence of such single-bonded oxygen atoms leads to lower density and to higher dielectric constant and refractive index.

The effect of heat treatment is to decrease the dielectric constant and to increase the density continuously as the temperature is lowered. The effect is greater for the glasses which contain the larger number of single-bonded oxygen atoms and the higher concentration of sodium ions.

The effect of sodium ions on the formation of single-bonded oxygen and the presence of such oxygen as a function of the composition of the glass offer a satisfactory explanation of the change in structure with composition and of the relation between composition and physical properties.

Department of Ceramics
Rutgers University
New Brunswick, New Jersey

FURTHER STUDIES OF GLASS FRACTURE WITH HIGH-SPEED PHOTOGRAPHY*

By H. E. Edgerton and F. E. Barstow

Abstract

Photoelastic photographs, with exposures of approximately one-millionth of a second, were taken of transient stresses in glass before, during, and after fracture. The longitudinal and transverse waves in glass have been photographed and their velocities measured (18,000 and 11,000 ft. per sec., respectively). It was also found that under special conditions cracks may travel slower than 5000 ft. per sec., the value previously given as the crack propagation velocity.

I. Introduction

In an earlier paper, the writers[1] showed a series of short-exposure spark-photographs of crack patterns in glass during fracture. The velocity of propagation of cracks was 5000 ft. per sec. for all samples tested, thus agreeing with the results of Schardin and Struth.[2] Neither the severity of the initiating blow nor the temper of the glass appeared to affect the velocity.

This investigation was continued, with emphasis placed on the photoelastic stress patterns accompanying the cracks. Stress concentrations at the tips of the rapidly moving cracks were photographed, but there did not appear to be a distinctive wave motion. Both transverse and longitudinal waves, more or less independent of the cracks, were photographed, however, and they were identified by their velocities of 11,000 and 18,000 ft. per sec., respectively. Apparently 5000 ft. per sec. is only the limiting velocity of cracks, inasmuch as they were started mechanically under certain conditions such that velocities from a few hundred to several hundred feet per second were obtained.

II. Apparatus

The apparatus used for high-speed photoelastic photographs (Fig. 1) was fundamentally the same as that described in the first paper.[1] Because of light losses in the polarizing media, however, a more intense source of light was required. This was obtained by increasing the voltage from 7000 to 15,000 volts and, in some cases, by using a small argon discharge tube instead of an open spark-gap. The exposures were approximately a millionth of a second. Sheets of polaroid, used to serve as polarizer and analyzer, were placed as shown in Fig. 1. No attempt was made to use monochromatic light nor were the samples in strictly parallel light. Quarter-wave plates were used only for a few of the sound-wave photographs (see Fig. 11). Cracks were started by driving a steel ball against the glass plate, an electric signal being obtained on contact of the plunger and breaking rod. The flashing of the spark was delayed about $^1/_{10,000}$ second after the signal was received in order to allow time for the crack to start.

A different optical system, used to measure the velocity of waves, yielded two complete separate but consecutive photographs of the same sample (this arrangement is shown and described in Fig. 11).

Glass reveals the photoelastic effect (that is, it becomes birefringent under stress) but to a lesser degree than certain plastics commonly used in photoelastic analysis because its coefficient of elasticity is only about $^1/_{18}$ that of transparent bakelite. Thus, even though but one or two bands appear in some of the accompanying photographs, the presence of stresses of relatively high magnitude is indicated. Except for the measure-

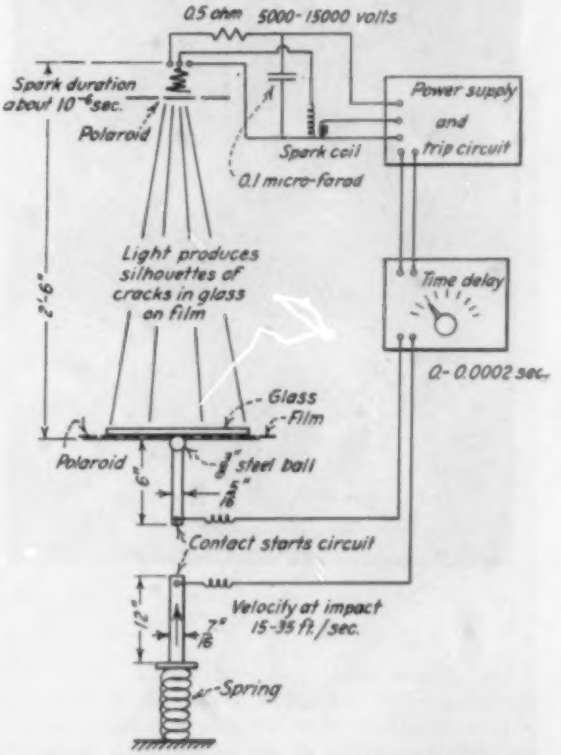

Fig. 1.—Apparatus used to obtain photographs of cracks or photoelastic patterns in glass during fracture.

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 10, 1940 (Glass Division). Received January 11, 1941.

This investigation was supported by funds from Corning Glass Works, Hartford-Empire Company, Hazel-Atlas Glass Company, Libbey-Owens-Ford Glass Company, Owens-Illinois Glass Company, and Pittsburgh Plate Glass Company.

[1] F. E. Barstow and H. E. Edgerton, "Glass Fracture Velocity," *Jour. Amer. Ceram. Soc.*, **22** [9] 302–307 (1939).

[2] H. Schardin and W. Struth, "Hochfrequenzkinematographische Untersuchung der Bruchvorgange im Glas," *Glastech. Ber.*, **16** [7] 219–27 (1938); *Ceram. Abs.*, **18** [1] 17 (1939).

ment of velocities, all work has been of a purely qualitative nature.

III. Results and Description of Photographs

The results of these photoelastic studies may be described best by an inspection of the accompanying drawings and photographs. Except where otherwise stated, the polarizer and analyzer were crossed at 90°, resulting in a black unstressed background.

Figure 1

Apparatus is shown for obtaining photographs of cracks or photoelastic patterns in glass during fracture. A time delay of approximately 10^{-4} seconds was required for the particular size of hammer shown. An adjustable electronic circuit was used to introduce this delay.

Figure 2

The photoelastic stress pattern in a 4- by 5-in. piece of $^1/_4$-in. plate glass during fracture is given. The fracture was started at the center of the plate by a blow of a steel ball. The polarizer and analyzer were crossed and parallel to the sides of the plate, resulting in a black background in the absence of stresses. The light cloudlike wisps, more or less parallel to the cracks, are due to reflections from the crack surfaces and are not to be considered as part of the stress pattern.

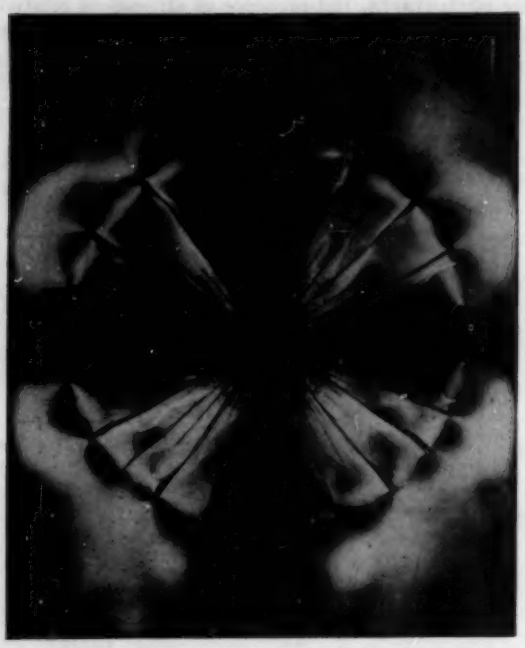

FIG. 2.—Photoelastic stress pattern in plate glass during fracture.

The Maltese-cross effect through the center, which showed up black on a similar photograph in color, is a set of isoclinics which rotate with the plane of polarization and show that in the absence of cracks the stresses are either circumferential or along a radius vector. This, however, may not be strictly true near the center as the applied stress is not in the plane of the glass but at right angles to it.

The local patterns around each moving crack tip show a concentration of stress at these points. The shorter stationary cracks, however, show little or no concentration of stress even though the whiteness all around them indicates that this region is still stressed. The stress at these points probably is radial.

Figures 3 and 4

Transient stress patterns in tempered glass are shown in Figs. 3 and 4. In Fig. 3, the blow was not quite sufficient to cause fracture.

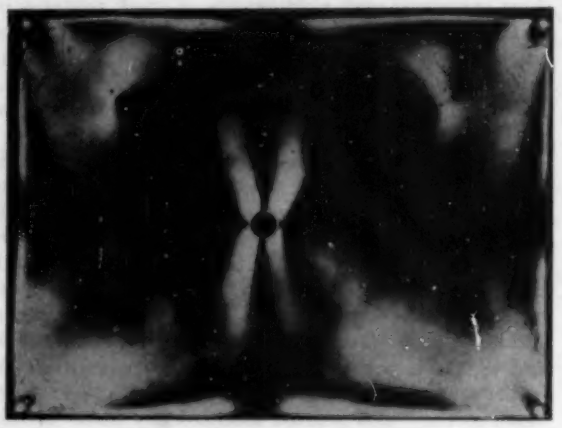

FIG. 3.—Transient stress patterns in tempered glass.

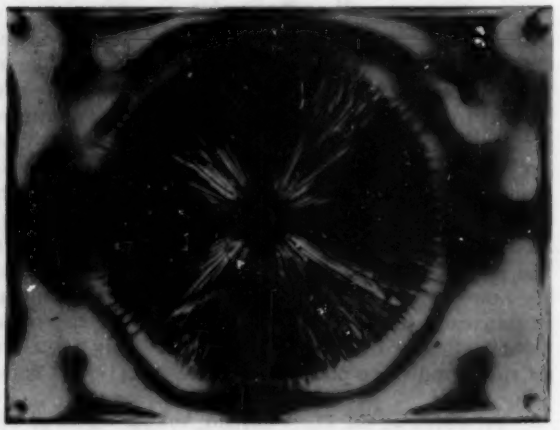

FIG. 4.—Transient stress patterns in tempered glass.

Figures 5 and 6

Figure 5 was made with polarizer and analyzer crossed and Fig. 6 with them parallel. These figures show the photoelastic pattern in a strip of $^1/_4$-in. glass when struck from the side. This arrangement for breaking reduces the problem to one strictly in two dimensions and also produces a single isolated crack. The position

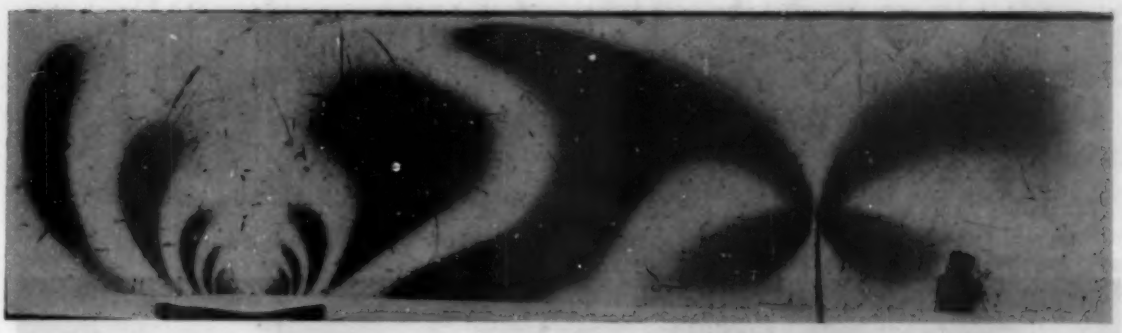

FIG. 5.—Photograph made with polarizer and analyzer crossed.

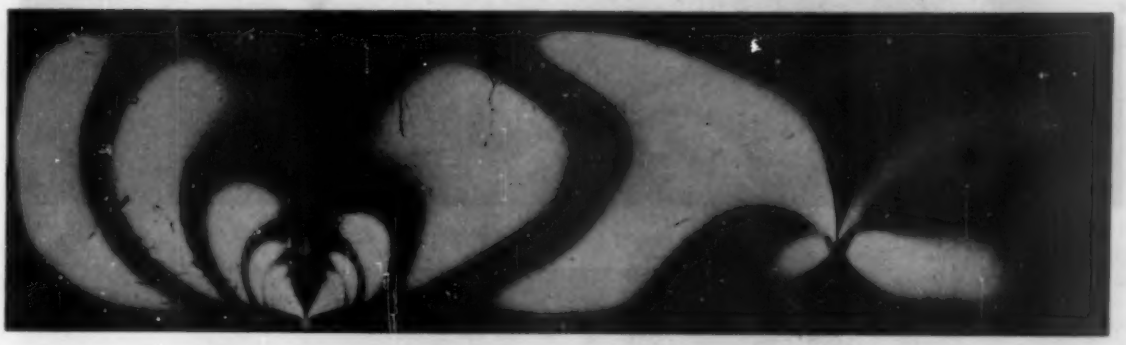

FIG. 6.—Photograph made with polarizer and analyzer parallel.

of the crack was determined by making a small scratch at the edge on the same side as the point of impact but some distance from it. These cracks usually followed a straight path halfway across the plate and then started to curve. Relatively little branching occurred from these cracks; their starting time was surprisingly constant and their velocity was 5000 ft. per sec.

The isochromatic bands tangent to the point of impact show the extreme stress concentration which is much greater at this point than at the crack tip. The leaves of the pattern around the crack do not appear to come to a point at the tip, but this is because the crack on one side of the glass preceded the crack on the other side. An inspection of the thermal cracks shows that the pattern comes to a point when the crack front is perpendicular to the glass surface. The stresses at a crack must be tensional only, inasmuch as the free surfaces of the crack can support no shear forces and the cracks therefore will follow a principal plane.

Figure 7

To be certain that the patterns around the crack tips were due to a simple concentration of stress and not to some dynamic condition resulting from the high velocity of the crack, several photographs (including Fig. 7) were made of slow-moving cracks driven by thermal stresses. The pattern is similar to those already shown and it disappeared when the plate cooled down, thus proving that the pattern (in the dynamic case) for the most part was the static concentration of stress. The stress shown at the bottom was due to the application of heat.

FIG. 7.—Slow-moving cracks driven by thermal stresses.

(1941)

FIG. 8.—High-speed moving picture of slow-moving cracks (1200 frames per sec.).

FIG. 9.—Wave motion and reflections.

FIG. 10.—Example of wave motion caused by a chip.

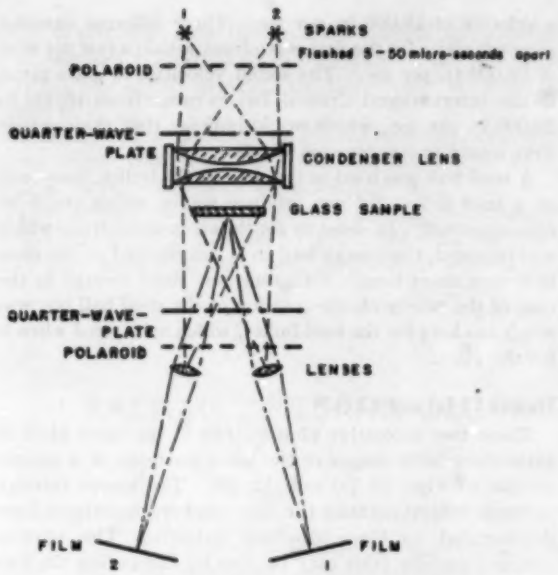

FIG. 11.—Arrangement for measuring velocities of waves in glass

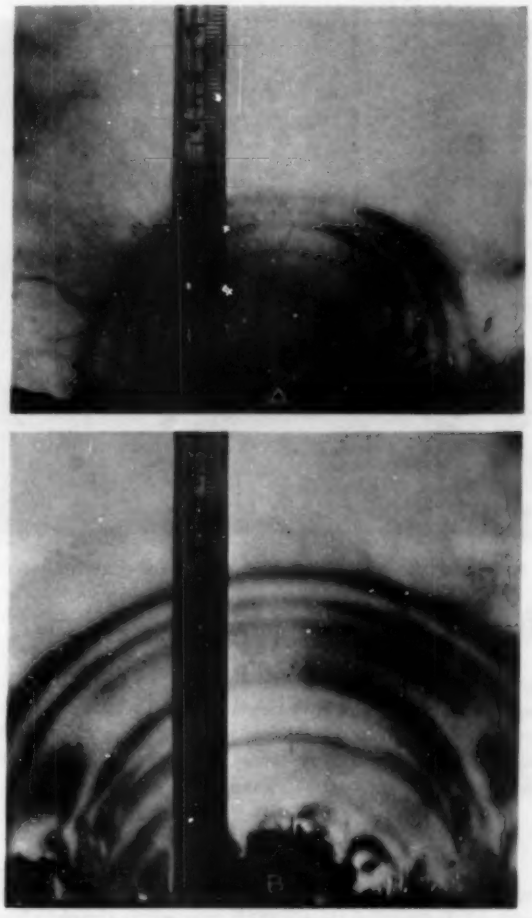

FIG. 12.—Compression waves in glass.

Figure 8

No glass cracks have been found that move faster than approximately 5000 ft. per sec. Cracks, however, that are driven by thermal stresses may be made to move very slowly. It seemed that intermediate velocities might be obtained by a relatively slow loading of the plate. A short crack was started by scratching and tapping the glass at one edge; a load was then applied slowly by turning down a screw. Figure 8 is a high-speed moving picture of the sample taken at 1200 frames per sec. The dark line extending downward from the top and increasing in length from frame to frame is the crack, with a centimeter and inch scale behind it. The velocity range of the crack shown here extends from about 2 ft. to more than 200 ft. per sec. (This experiment, however, still does not rule out the possibility that the cracks may be moving in small jumps, and their velocity while moving is always 5000 ft. per sec.) Apparently 5000 ft. per sec. is a maximum or limiting velocity. A certain minimum value of stress in the vicinity of the tip seems to be required for the crack to propagate. If this value exists throughout the plate when the crack first starts, it will propagate at the maximum velocity of 5000 ft. per sec.; otherwise it will propagate only as fast as the required stress moves through the plate. In the present case of a plate struck by a steel ball, this required stress for propagation apparently was reached throughout the plate before the crack first started so that its velocity appears everywhere to be 5000 ft. per sec.

Figure 9

The photoelastic patterns presented up to this point have had none of the characteristics of waves, but in Fig. 9 a definite wave motion, even to reflections, is shown. The origin seems to have been the point of impact. Notice that the waves had not quite reached the crack on the right at the time of exposure, showing that it was independent of the wave. Experiments showed that the wave was generated when the chip seen near the point of impact was released. The chip apparently was released rapidly but at a relatively long time after the start of the impact.

Figure 10

Figure 10 shows another example of waves caused by a chip. The plate was struck again on the edge. The velocity of waves similar to these was measured for four samples, and it was found to be about 11,000 ($\pm 8\%$) ft. per sec., approximately the theoretical velocity of transverse waves in glass.

Figure 11

The velocities of waves and cracks were measured by taking two photographs a known interval apart from which the velocities were calculated. In the case of cracks, the exposures were superimposed on the same film, but this gave too complicated a pattern in the case of waves. To separate the two exposures, the optical arrangement was used as described, in which light from the two sources was separated and directed onto separate films by the large condenser lens. The glass sample, which was placed just below the condenser lens where it received light from both sources, was focused by two small lenses onto the films. The time interval between exposures (about 7 micro-

seconds in the case of waves) was measured simultaneously on an oscillograph.

Polarizer, analyzer, and quarter-wave plates (which were made from sheets of cellophane) were placed as shown. This type of setup is not confined to two exposures and, as used by Schardin,[8] gives a sequence of pictures of extremely high frequency.

Figures 12 (a) and 12 (b)

The velocity of 11,000 ft. per sec. for waves of the type shown in Figs. 9 and 10 indicated that they were transverse waves. In order to obtain compression or sound waves, a 0.22 rifle bullet with a $^5/_{32}$-in. steel ball inserted in the nose was fired at the edge of a $^1/_4$-in. glass plate. Using parallel polaroids and quarter-wave plates in the setup of Fig. 10, these two successive photographs of the resulting stress waves in the same piece of glass were obtained. The time interval between exposures was $4^3/_4$ microseconds, and the distance traveled by the wave was 2.7 cm., giving a velocity of 18,600 ft. per sec. Three different samples gave velocities for the first wave front within a few per cent of 18,000 ft. per sec. The sound velocities in glass given in the International Critical Tables range from 16,000 to 20,000 ft. per sec., which would indicate that these waves were sound or compression waves.

A steel ball was used in the nose of the bullet, inasmuch as a lead bullet did not produce waves which could be photographed. In order to get the steep wave-front which was required, the energy had to be transferred to the glass in a very short time. This time was short enough in the case of the nearly elastic collision of the steel ball but was much too long for the lead bullet, which splattered when it hit the glass.

FIG. 13.—Later stages of wave patterns, similar to those in Fig. 12.

Figures 13 (a) and 13 (b)

These two successive photographs of the same piece of glass show later stages of the wave patterns of a sample similar to Figs. 12 (*a*) and 12 (*b*). The waves through multiple reflections from the edges and crack surfaces have degenerated to these jumbled patterns. The pattern changed rapidly (this may be seen by comparing the two photographs which were taken only five or ten microseconds apart). Parallel polaroids and quarter-wave plates again were used in this case.

FIG. 14.—View of glass piece struck on edge by bullet.

Figure 14

A still later view of a piece of glass struck on the edge by a bullet shows that the jumbled patterns have disappeared, the cracks have developed farther, and the dark area around the point of impact indicating fracture has extended nearly halfway across the plate. The polaroids were parallel, and quarter-wave plates were used.

IV. Conclusions

Crack velocities of mechanical breaks were obtained, ranging from several feet to several hundred feet per second, indicating that 5000 ft. per sec. is simply a limiting velocity. It would seem that a certain minimum

value of stress near the tip of a crack is required to cause it to propagate, its velocity (up to 5000 ft. per sec.) depending on the rate at which the stress value is built up ahead of it.

Transient photoelastic photographs indicated a strong stress concentration at the crack tip, which was pure tension at right angles to the crack.

Two different stress waves were photographed, and their velocities of 11,000 and 18,000 ft. per sec. indicated that they were transverse and longitudinal waves, respectively. The transverse waves were caused by the sudden breaking out of a chip around the point of impact on the edge of the glass, whereas the longitudinal waves were caused by the impact of a bullet nosed with a steel ball. No direct connection between the waves and the cracks was apparent from the photographs.

Department of Electrical Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts

FACTORS AFFECTING SAGGING TESTS ON ENAMELING IRON*

By J. E. Sams, William McGohan, and J. J. Canfield

Abstract

A method is described by which sagging tests may be made and the determinations may be duplicated with considerable accuracy. The effect of different furnaces is noted as well as such factors as furnace size, temperature and its control, width of samples, enamel coating, time of testing, size of sample, and metal composition.

I. Introduction

Sagging or downward bending of enameling iron during the enamel firing process may create a number of undesirable effects. A change in the shape of the iron caused by sagging may result in difficulty in assembling the enameled parts, thereby producing chipping immediately or at a later time. A lack of flatness may also detract from the appearance and the saleability of the finished product.

The terms "sagging" and "warping" may sometimes be used interchangeably. Sagging, which is the downward bending of the metal between supports, is caused by the inability of the metal to support its own weight at enameling temperature. Warping is a change of the metal shape caused by relief of stresses in the metal. These stresses are often placed in the metal by some drawing or forming operation. Warping, however, may be a direct result of sagging, which in this case occurs on horizontal sections and causes a twisting of adjacent sections.

Sagging has been measured in some plants by the method described by Butts.[1] A bare metal strip, 1/2 in. wide and 9 5/8 in. long, was supported on a rack 8 7/8 in. between supports. After heating for 10 minutes at 1600°F., the change in deflection at the middle of the sample was measured. Porter[2] and Bisbee[3] have described similar tests for measuring the sag of bare metal samples. Some enameling plants have made sagging tests by heating metal strips in a continuous furnace at the usual ground-coat firing temperatures.

The sagging results obtained by these methods sometimes have shown wide variation for no apparent reason. A committee of the Porcelain Enamel Institute is working on a standard sagging test which may be used in different laboratories and plants to obtain results which can be correlated. A possible reason for the absence of a standard test has been the lack of equipment, such as furnaces which are comparable in construction and control.

A few observations made in the laboratory by the writers indicate that a standard sagging test is possible if certain test conditions are brought under control.

II. Experimental Tests

It was found in preliminary tests that all of the factors, such as furnace size, its control, the temperature used, time of heating, and the use of coated samples, affected the amount of sagging of the iron. Samples sagged less when they were tested in a large furnace which had a comparatively slower heating rate than when heated in a smaller furnace having a more rapid heating rate even though the controls were set for the same temperature. It was also observed that bare or uncoated metal samples would sometimes sag suddenly during cooling after their removal from the furnace, and this was believed to be related to sudden breaking of the scale. This behavior caused nonuniform results on strips taken side by side from the same sheet.

The following conditions for the determination of metal sagging therefore were adopted. The instrument used to measure the samples for the sagging tests is shown in Fig. 1. The samples are supported on 1/4-in., parallel, horizontal rods, spaced so that the contacts are 10 in. apart. The deflection from the hori-

---

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 9, 1940 (Enamel Division). Received April 9, 1940; revised copy received August 27, 1940.

[1] Homer Butts, "Checking Sag-Resisting Properties of Enameling Iron," *Better Enameling*, **3** [6] 21 (1932); *Ceram. Abs.*, **11** [12] 607 (1932).

[2] F. R. Porter, "Sag-Resisting Properties of Enameling Iron," *Jour. Amer. Ceram. Soc.*, **22** [6] 176–79 (1939).

[3] R. F. Bisbee, "Inspection, Packing, amd Field Problems," *Better Enameling*, **10** [11] 12 (1939).

zontal plane is measured at the center of the strip before and after heating by means of an attached micrometer screw. Different readings of the amount of sag on the same sample may be duplicated within a spread of 0.004 in. The accuracy of the sagging determinations is thus not limited by the method of measurement, as sagging values taken to the nearest $^1/_{100}$ inch are adequate for the interpretation of the usual variation in results.

FIG. 1.—Rack for measuring sag.

Figure 2 shows the rack used to support the samples during heating, which is made of $^1/_4$-in. heat-resisting alloy rod and is 7 in. high with a 10- by 11-in. top. The samples rest on the rack with 10 in. between supports.

The furnace used is shown in Fig. 3. A protecting shell of 16-gauge iron-chromium alloy helps to maintain uniform temperature in the zone where the samples are heated; the shield is 14 in. wide, 12 in. high, and 29 in. long. Bare thermocouples extend through the back wall of the furnace. Close control of furnace tempertures is obtained by the use of a proportioning controller, a calibrated bare thermocouple, and a minimum power input necessary to maintain the required temperature. Figure 4 shows the recorded charts obtained with various types of thermocouples and differing amounts of power input. In (*A*), three factors, namely, more power input than necessary to hold the furnace at 1600°F., the use of an inclosed couple, and the use of a regular potentiometric controller, contributed to a tendency to over-ride the desired temperature. This tendency is much less in (*B*), where the power input is closer to the minimum. Chart (*C*) shows that over-riding does not occur when a bare thermocouple and a proportioning controller are used. The heating curves of several sagging tests in the forepart of (*C*) indicate close control of furnace temperature.

The sagging tests described here, unless otherwise

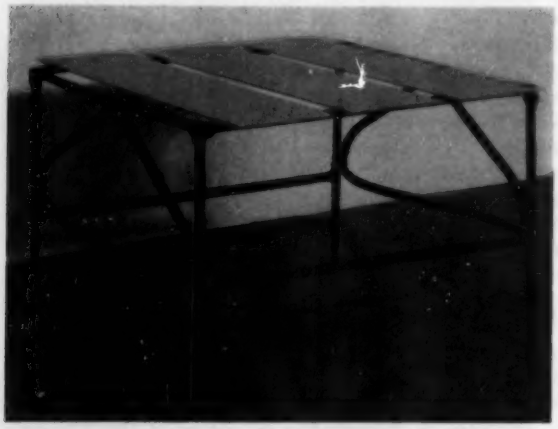

FIG. 2.—Rack for heating sag samples.

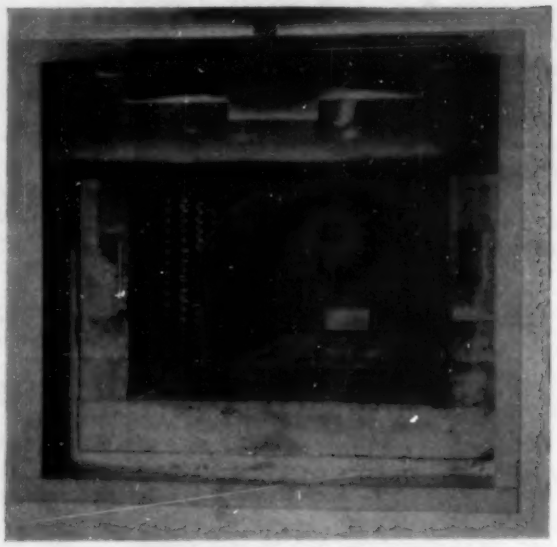

FIG. 3.—Furnace used for sagging tests

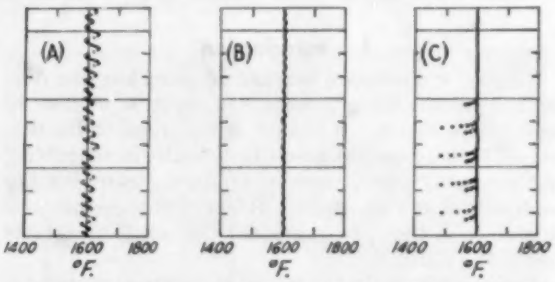

FIG. 4.—Furnace control charts: (*A*) recording potentiometer pyrometer with inclosed thermocouple and high power input; (*B*) recording potentiometer pyrometer with inclosed thermocouple and low power input; (*C*) proportioning controller with bare thermocouple and low power input.

stated, were made as follows: Samples of 20-gauge enameling iron, 3 by 12 in., with the length parallel to the rolling direction, were cleaned, pickled, and coated with enamel. A coating of about 18.5 to 21.5 gm. of dry enamel per square foot of surface was used. On the underside of the sample, where contact was made with the firing rack, the enamel was brushed away in a band about 1 in. wide to prevent sticking. After thoroughly soaking the furnace, the samples were heated 10 minutes at 1600°F. on the firing rack. Clay was applied to the rack as an additional precaution against sticking of the samples. The rack was cooled before each sag test.

III. Test Results

(1) Effect of Weight of Enamel Coating

Groups of samples, 3- by 12-in. in size, were selected in a diagonal pattern from a 20-gauge enameling iron sheet and were coated with different weights of enamel. The results, shown in Fig. 5, which are the average for 5 or more samples, indicate that the sagging is practically constant when a coating weight of 18.5 to 21.5 gm. of dry enamel per square foot of surface is used.

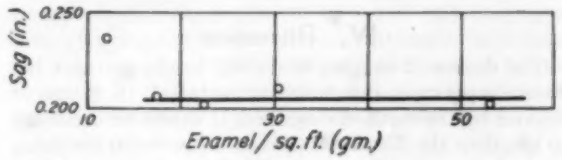

FIG. 5.—Effect of enamel coating on sagging of metal.

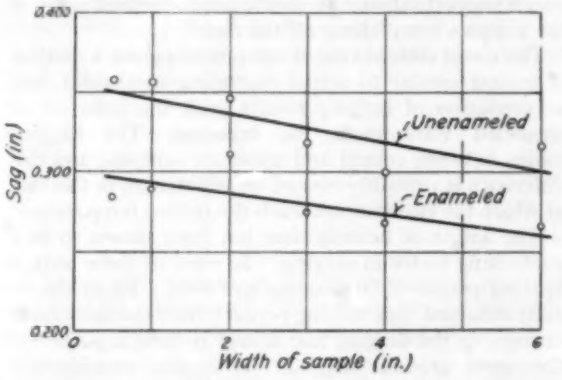

FIG. 6.—Effect of width of sample on sagging of metal.

The sagging is not constant on samples with very light weights of enamel coatings. The enamel tends to overfire rapidly and to become saturated with iron oxide. The sagging values apparently approach those obtained on uncoated samples, which have been found to be higher than for the coated samples (Fig. 6).

(2) Effect of Width of Sample

A series of samples, 12 in. long and of different widths, was cut somewhat at random from a 20-gauge enameling iron sheet but parallel to the rolling direction. Sagging tests on 5 samples of each width were made on enameled and on unenameled pieces. Figure 6 shows the results obtained.

The wider samples sagged less than narrow ones. The results show that the differences in the amount of sagging of these samples probably are due to differences in the heating rate and time at the maximum temperature in the test.

(3) Effect of Testing Time

Groups of samples were chosen as in the tests for width from a 20-gauge enameling sheet. The length was cut parallel to the rolling direction; the 3- by 12-in. samples were selected in a diagonal pattern and were heated at 1600°F. for varying lengths of time. The results are shown in Fig. 7.

The sagging changes rapidly during heating periods of 5 minutes or less, and it increases at an approximately constant rate when a heating time of 10 minutes or longer is used.

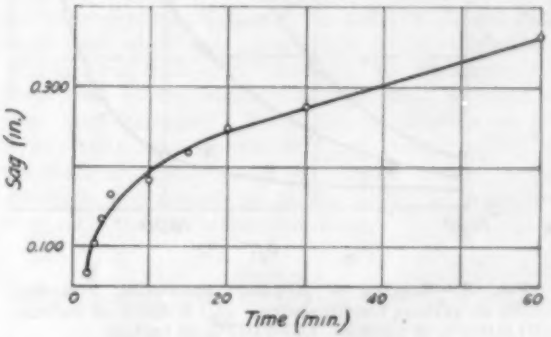

FIG. 7.—Effect of heating time on sagging of metal.

(4) Effect of Temperature

Samples were selected and tested as before except that the temperature rather than time was varied. Each sample was heated for 10 minutes at the particular temperature used.

The results are shown in Fig. 8. Curve (*A*) indicates that the sagging of the enameling iron increases slowly with the temperature up to about 1550°F. and then begins to increase rapidly. It has been determined from this curve that a variation of 8°F. in the furnace temperature range near 1550°F. would cause a variation of 0.01 in. in sagging; a variation of only 4°F. of furnace temperature near 1600°F. would produce the same variation in sagging; and near 1650°F., there is a rapid rise in the amount of sagging.

(5) Effect of Metal Composition

Sagging tests have been made on enameling iron and steels at various temperatures. The results obtained on enameling iron containing 0.017% of carbon and on two steels containing 0.034 and 0.065% of carbon are shown in Fig. 8 by curves designated as *A*, *B*, and *C*, respectively. The sagging of each metal is shown to increase with an increase in temperature; the enameling iron, however, sags much less than the steels, particu-

larly in the enamel firing range of 1500° to 1600°F. This property is due chiefly to composition and is the basis for production of flatter ware.

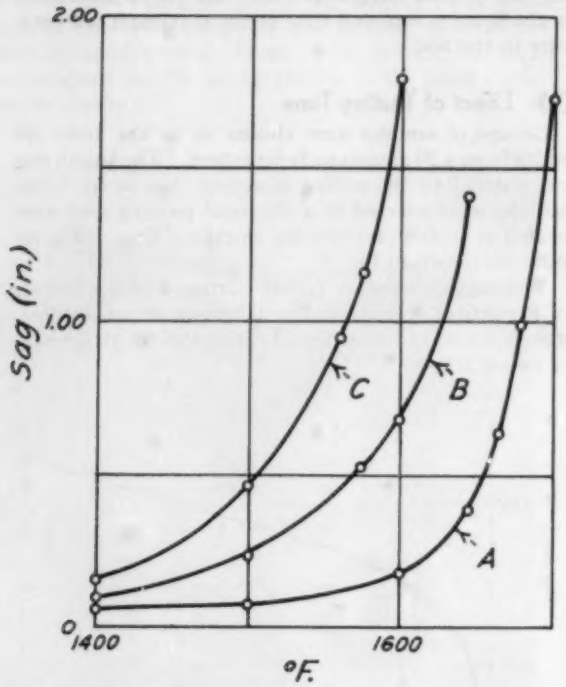

FIG. 8.—Sagging of 20-gauge enameling iron and steels at various temperatures; (*C*) 0.065% of carbon; (*B*) 0.034% of carbon; (*A*) 0.017% of carbon.

(6) Uniformity of Sagging Results

Table I shows results obtained on samples selected as described from a 20-gauge sheet of enameling iron.

The results show a maximum variation of 0.018 in. This slight variation is not always obtained, but the uniformity in many determinations indicates that the method is rather accurate. Large variations in sagging results therefore indicate either a lack of control in the method or a variation produced by some external cause.

TABLE I
UNIFORMITY OF SAGGING DETERMINATIONS

Sample No.	Thickness (in.)	Sag correction (in.)	Measured sag (in.)	Corrected sag (in.)
1		+0.006	0.276	0.282
2	0.038	+0.012	0.266	0.278
3		+0.011	0.256	0.267
4		+0.005	0.280	0.285
5		+0.000	0.278	0.278

(7) Effect of Wavy Samples

Samples were selected as before but from a very wavy sheet. The sagging results are given in Table II. The sag corrections are shown and designated as positive or negative. The positive values indicate that the metal sample resting on the measuring rack is bowed upward from the horizontal plane; the negative values indicate a downward bow. The measured sag is the amount of downward bending from the horizontal plane after the sample has been heated. The actual amount of sagging which occurs during the test is the total change in deflection and is designated as corrected sag.

TABLE II
SAGGING OF WAVY METAL

Sample No.	Thickness (in.)	Sag correction (in.)	Measured sag (in.)	Corrected sag (in.)
1		−0.115	0.388	0.273
2	0.038	+0.080	0.146	0.226
3		+0.072	0.197	0.269
4		0.000	0.222	0.222
5		−0.032	0.227	0.195

Table II shows that the deviation of the measured sag values is much greater than the corrected values. The total spread of the corrected values in this test is less than one third of the uncorrected values.

These data do not indicate that waviness of the metal is without influence on sagging. A sample may be bent lengthwise and the sagging resistance may be materially strengthened; this stiffening effect is obtained on panels by certain types of embossing.

IV. Discussion

The degree of sagging is related to the distance between supports. For tests on metal of 16 gauge or heavier by the method described, it would be necessary to lengthen the distance between supports on the firing rack to increase the accuracy of measurement. For gauges lighter than about 22 gauge, the distance between supports should be shortened to prevent some of the samples from falling off the rack.

The use of enamel-coated samples has given a method of testing similar to actual enameling conditions, and a correlation of sagging results with the behavior of enameled ware might be expected. The sagging varies between coated and uncoated samples, and this difference is probably caused by differences in the rate at which the two samples reach the testing temperature.

The length of heating time has been shown to be a controlling factor in sagging. In most of these tests, a heating period of 10 minutes was used. From the results obtained, this heating period covers the more rapid changes in the sagging and it may include a portion of the more gradual sagging. It is also considerably longer than the usual enamel-firing time, but a sag-testing period of 10 minutes or longer is necessary to avoid wide variations in sagging results.

There are a number of factors which govern the rate of heating and the time at which the metal remains at the testing temperature. Such factors as the size and shape of the sample, the size of the furnace, and the power input and control are important, and they must be controlled in order to obtain comparative results. Consistent results have been obtained by the use of enamel-coated samples, heated in a closely controlled furnace, and it would be necessary to standardize all of these factors to establish a standard sagging test.

AMERICAN ROLLING MILL COMPANY
MIDDLETOWN, OHIO

USE OF A HIGH SERICITE PYROPHYLLITE IN VITREOUS BODIES*

By Emerson W. Emrich

Abstract

A pyrophyllite containing approximately 15% of sericite is being produced at Hemp, North Carolina. When it is substituted in vitreous bodies for all of the flint or all of the flint and some feldspar, a marked increase in fired strength results, and the shrinkage and absorption properties are not affected by this substitution. The types of bodies studied include electrical porcelain, made by the dry and plastic processes, sanitary ware, vitreous floor tile, and hotel chinaware.

I. Introduction

There are two definite types of pyrophyllite deposits in North Carolina. One type is associated with a considerable amount of sericite and the other is practically free from this material. In describing these pyrophyllite deposits, Greaves-Walker[1] states that the Hemp and Glendon deposits contain more or less sericite, whereas the Staley and Snow Camp deposits are of the free type.

(1) Object of Study

The effect of the high sericite (to be denoted as HS) pyrophyllite content from Hemp on vitreous ceramic bodies was made the object of this investigation. During the past ten years, attempts have been made to use pyrophyllite which contains little or no sericite in vitreous bodies, but satisfactory results have not been obtained. Excellent results, however, are to be noted with the use of HS pyrophyllite.

(2) Properties of HS Pyrophyllite

The general formula of pyrophyllite is $Al_2O_3 \cdot 4SiO_2 \cdot H_2O$ and that of sericite is $K_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$.

The chemical composition of the HS pyrophyllite from Hemp is as follows:

	(%)		(%)
SiO_2	80.05	MgO	0.20
Al_2O_3	15.56	K_2O	1.39
Fe_2O_3	0.09	Na_2O	0.20
TiO_2	0.12	Ignition loss	2.35
CaO	0.16		
			100.12

The sericite content of HS pyrophyllite is approximately 15%, and the tabular data show the approximate percentage of sericite for a given alkali content.

Alkalis (%)	Sericite (%)	Alkalis (%)	Sericite (%)
0.5	4.2	1.2	10.2
.6	5.1	1.3	11.0
.7	5.9	1.4	11.9
.8	6.8	1.5	12.7
.9	7.6	2.0	17.0
1.0	8.5	2.5	21.2
1.1	9.3	3.0	25.4

* Presented at the Autumn Meeting, White Wares and Materials and Equipment Divisions, Uniontown, Pa., September 14, 1940. Received July 10, 1940.

Thesis presented for the Professional Degree of Ceramic Engineer, The Ohio State University, June, 1940.

[1] A. F. Greaves-Walker, C. W. Owens, Jr., T. L. Hurst, and R. L. Stone, "Development of Pyrophyllite Refractories and Refractory Cements," *Univ. of N. C. Eng. Expt. Sta. Bull.*, No. 12, p. 12 (1928).

II. Tests

The tests were made in the usual manner, that is, by substituting one material directly for another in a series of bodies. No attempt was made to keep the alkali content of the bodies constant.

(1) Electrical Porcelain Bodies

The effect of substituting HS pyrophyllite for the flint and some of the feldspar in electrical porcelain bodies is given in Tables I, II, and III. These data show that when HS pyrophyllite is substituted for flint there is little or no change in the shrinkage and absorption of the bodies but their fired strength is materially increased. With the substitution of HS pyrophyllite for all of the flint and from 2 to 5% of the feldspar, there is still no marked change in the shrinkage and absorption of the body, but a further increase in the fired strength is noted.

Table I

HS Pyrophyllite in Dry-Pressed Insulator Bodies

Body No.	Composition (%) 1	2	3	4	5
Flint	17.0	10.0			
N. C. A-2 feldspar	37.0	37.0	37.0	35.0	33.0
Ky.-Tenn. Clay Co. No. 4 ball clay	8.0	8.0	8.0	8.0	8.0
Bell Dresden ball clay	8.0	8.0	8.0	8.0	8.0
Cherokee clay	10.0	10.0	10.0	10.0	10.0
Edgar Fla. kaolin	10.0	10.0	10.0	10.0	10.0
English china clay	10.0	10.0	10.0	10.0	10.0
HS Pyrax pyrophyllite		7.0	17.0	19.0	21.0
Cone No.	Absorption of dry weight (%)				
6	6.3	6.1	5.6	5.4	5.8
7	5.5	5.0	4.9	4.1	5.1
8	3.8	3.6	3.6	3.4	4.5
9	2.4	2.3	2.1	2.5	3.4
10	1.0	1.0	1.3	1.3	1.8
11	0.1	0.3	0.1	0.2	0.1
	Total shrinkage of green length (%)				
6	6.9	6.9	6.8	6.8	6.4
7	7.2	7.3	7.2	7.1	6.7
8	7.6	7.6	7.5	7.6	7.2
9	7.9	8.0	8.1	8.1	7.6
10	8.5	8.6	8.5	8.4	8.1
11	9.2	9.2	9.1	9.0	9.0
	Modulus of rupture (lb./sq. in.)				
11	7790	7830	8440	8670	8560
	Pressed with 10% of water (% strength increase)				
11		0.5	8.3	11.3	9.7

TABLE II

ELECTRICAL INSULATOR BODIES

Body No.	6	7	8	9	10
	Composition (%)				
Jasper flint	17.0	10.0			
Derry feldspar	38.0	38.0	38.0	35.0	33.0
Ky.-Tenn. Clay Co. No. 4 ball clay	10.0	10.0	10.0	10.0	10.0
Ky. Clay Mining Co. KCM ball clay	8.0	8.0	8.0	8.0	8.0
Peerless S. C. kaolin	10.0	10.0	10.0	10.0	10.0
Edgar Fla. kaolin	10.0	10.0	10.0	10.0	10.0
Harris Lunday N. C. kaolin	7.0	7.0	7.0	7.0	7.0
HS Pyrax pyrophyllite		7.0	17.0	20.0	22.0
Cone No.	Absorption of dry weight (%)				
4	7.4	8.0	8.0	8.4	8.7
5	6.1	6.3	6.4	7.0	7.0
6	5.0	5.3	5.4	5.8	6.3
7	3.5	4.1	4.4	4.9	5.2
8	2.5	2.8	3.0	3.6	4.1
9	1.1	1.3	1.3	1.8	2.0
10	0.5	0.8	0.7	0.9	1.1
12	0.0	0.0	0.0	0.0	0.0
	Total shrinkage of green length (%)				
4	7.4	7.1	7.0	7.0	6.8
5	7.8	7.6	7.5	7.5	7.4
6	8.3	8.1	8.1	8.0	7.8
7	8.7	8.6	8.5	8.4	8.0
8	9.4	9.2	9.1	9.0	8.7
9	10.1	9.8	9.8	10.0	9.5
10	10.4	10.4	10.1	10.1	9.9
12	10.5	10.6	10.4	10.6	10.5
	Modulus of rupture (lb./sq. in.)				
10	7950	8070	8500	8800	9180
12	8170	8750	9680	9950	10000
	Pressed with 12% of moisture (% strength increase)				
10		1.5	6.9	10.7	15.5
12		7.1	18.5	21.8	22.4

TABLE III

ELECTRICAL INSULATOR BODIES

Body No.	11	12	13	14	15	16
	Composition (%)					
Jasper flint	25.0	15.0	5.0	25.0	15.0	5.0
Derry feldspar	20.0	20.0	20.0	30.0	30.0	30.0
Ky.-Tenn. Clay Co. No. 4 ball clay	20.0	20.0	20.0	10.0	10.0	10.0
Ky. Clay Mining Co. KCM ball clay	15.0	15.0	15.0	10.0	10.0	10.0
Peerless S. C. kaolin	10.0	10.0	10.0	15.0	15.0	15.0
Edgar Fla. kaolin	10.0	10.0	10.0	10.0	10.0	10.0
HS Pyrax pyrophyllite		10.0	20.0		10.0	20.0
Cone No.	Absorption of dry weight (%)					
6	10.2	10.0	9.7	8.2	7.6	7.2
7	8.3	8.1	8.0	6.7	6.0	5.5
8	7.5	7.3	7.0	5.9	5.4	4.1
9	5.6	5.4	5.0	4.4	4.0	3.2
10	5.5	5.4	5.2	2.0	1.3	0.9
11	3.8	3.2	2.6	1.0	0.9	0.4
12	1.9	1.8	1.8	0.2	0.1	0.0
13	0.7	0.4	0.3	0.0	0.0	0.0
	Total shrinkage of green length (%)					
6	6.5	6.8	6.9	6.8	6.9	7.2
7	7.3	7.5	7.7	7.5	7.7	7.9
8	7.6	7.9	8.0	8.0	8.1	8.2
9	8.4	8.7	8.9	8.5	8.7	8.9
10	8.6	8.8	9.1	8.8	9.0	9.2
11	9.7	9.8	10.0	9.5	9.7	10.0
12	9.9	10.3	10.5	9.9	10.0	10.2
13	10.7	10.9	10.9	10.5	10.5	10.7
	Modulus of rupture (lb./sq. in.)					
11	5850	6240	6400	6360	6440	7650
12	6150	6400	6550	6570	7630	8000
13	6530	7210	8270	7890	9030	9630
	Strength increase (%)					
11		6.7	9.4		1.3	20.3
12		4.1	6.5		16.1	21.8
13		10.4	26.7		14.4	22.1

TABLE IV

SANITARY-WARE BODIES

Body No.	17	18	19	20	21
	Composition (%)				
Jasper flint	20.0	10.0	5.0		
N. C. A-2 feldspar	30.0	30.0	30.0	30.0	25.0
Ky.-Tenn. Clay Co. No. 5 ball clay	10.0	10.0	10.0	10.0	10.0
M. & M. English ball clay	10.0	10.0	10.0	10.0	10.0
No. 333 English china clay	20.0	20.0	20.0	20.0	20.0
Peerless S. C. kaolin	10.0	10.0	10.0	10.0	10.0
HS Pyrax pyrophyllite		10.0	15.0	20.0	25.0
Cone No.	Absorption of dry weight (%)				
3	7.9	8.1	8.0	8.5	10.7
4	7.2	7.3	7.4	7.4	9.3
5	6.8	6.8	6.7	6.6	8.7
6	4.6	4.8	4.7	4.9	7.4
7	3.3	3.5	3.4	3.7	5.6
8	2.5	2.7	2.8	2.7	4.0
9	1.3	1.8	1.6	1.9	3.2
10	0.1	0.2	0.2	0.0	0.7
11	0.0	0.0	0.0	0.0	0.0

Cone No.	Body No.	17	18	19	20	21
		Total shrinkage of green length (%)				
3		7.5	7.6	7.7	7.7	7.7
4		8.0	8.1	8.2	8.1	8.1
5		8.6	8.5	8.5	8.7	8.7
6		9.7	9.6	9.3	9.4	9.3
7		10.0	10.1	10.0	10.1	10.1
8		10.5	10.4	10.3	10.4	10.3
9		11.0	11.0	10.7	11.3	11.0
10		11.6	11.4	11.6	11.5	11.6
11		12.0	11.7	11.6	12.0	12.0
		Modulus of rupture (lb./sq. in.)				
11		6050	6700	7320	6420	5570
		Strength increase (%)				
11			10.7	21.0	6.1	−7.9

TABLE V

SANITARY-WARE BODIES

Body No.	22	23	24	25
	Composition (%)			
Jasper flint	20.0	10.0		
Maine feldspar	30.0	30.0	30.0	25.0
Ky.-Tenn. Clay Co. No. 5 ball clay	10.0	10.0	10.0	10.0
Ky. Clay Mining KCM ball clay	10.0	10.0	10.0	10.0
Edgar No-Karb Ga. kaolin	10.0	10.0	10.0	10.0
Peerless S. C. kaolin	15.0	15.0	15.0	15.0
Harris Lunday N. C. kaolin	5.0	5.0	5.0	5.0
HS Pyrax pyrophyllite		10.0	20.0	25.0
Cone No.	Absorption of dry weight (%)			
4	10.2	12.0	12.5	13.7
6	7.0	7.7	7.9	10.3
7	6.4	7.0	7.7	9.3
8	3.9	5.0	5.6	8.5
9	3.5	4.5	5.2	7.2
10	2.1	2.8	3.1	5.3
11	1.0	1.5	2.0	4.3
12	0.3	0.4	0.7	2.3
	Total shrinkage of green length (%)			
4	7.3	7.0	7.0	6.9
6	9.0	8.7	8.2	7.7
7	9.3	9.0	8.9	8.7
9	10.0	9.7	9.6	9.4
10	10.3	10.0	10.0	10.0
11	11.0	10.7	10.8	10.4
12	11.5	11.3	11.2	10.5
	Modulus of rupture (lb./sq. in.)			
10	5100	5650	5690	4380
12	6300	6770	6830	4500
	Strength increase (%)			
10		10.8	11.6	−14.1
12		7.5	8.4	−28.6

TABLE VI

FLOOR TILE BODIES

Body No.	26	27	28	29
	Composition (%)			
Jasper flint	10.0			
Derry feldspar	58.0	58.0	55.0	52.0
EPK Fla. kaolin	15.0	15.0	15.0	15.0
Ky.-Tenn. Clay Co. No. 4 ball clay	7.0	7.0	7.0	7.0
Peerless S. C. kaolin	10.0	10.0	10.0	10.0
HS Pyrax pyrophyllite		10.0	13.0	16.0
Cone No.	Absorption of dry weight (%)			
5	1.9	1.6	2.1	2.0
6	2.2	1.3	1.7	1.8
7	1.2	0.7	1.2	1.5
8	0.2	0.0	0.1	0.4
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	O.F.*	O.F.*	O.F.*	O.F.*
	Total shrinkage of green length (%)			
5	10.2	10.4	9.9	9.4
6	10.4	10.6	10.3	10.0
7	10.8	11.0	10.7	10.4
8	11.2	11.4	11.2	10.9
9	11.4	11.5	11.3	11.2
10	11.4	11.4	11.3	11.3
11	O.F.*	O.F.*	O.F.*	O.F.*
	Modulus of rupture (lb./sq. in.)			
10	7400	7890	8100	8480
	Strength increase (%)			
10		6.6	9.5	14.6

* Overfired.

This increased strength is probably caused by the formation of mullite with its resulting interlocking grain structure. Some types of sericite are known to form mullite in the presence of pyrophyllite. Kerr[2] has shown that pinite, which is largely sericite, changes to mullite at comparatively low temperatures.

(2) Sanitary-Ware Bodies

The same type of substitution of HS pyrophyllite for flint has been carried out in several sanitary-ware bodies (Tables IV and V) as in electrical porcelain bodies, with the same general effect on shrinkage, absorption, and modulus of rupture. In this series, the substitution of HS pyrophyllite for all of the flint and 5% of the feldspar resulted in a definite decrease in fired strength. In body No. 25, this decrease was undoubtedly due to the nonmaturing of the body.

(3) Vitreous Floor Tile

Table VI shows that the substitution of HS pyrophyllite for the flint and some of the feldspar in floor-tile bodies definitely increases the fired strength without any marked change in the shrinkage and absorption of the bodies.

(4) Vitreous China Bodies

The use of pyrophyllite injures the jiggering properties of plastic bodies. When HS pyrophyllite is calcined, this difficulty is overcome, and the pyrophyllite retains all of the advantages of the natural material.

Table VII shows that the direct substitution of up to 20% of the flint results in a marked increase in fired strength. The shrinkage and absorption of the entire series remains uniform.

With an increase in pyrophyllite, however, there is a corresponding decrease in translucency. This is to be expected as the formation of mullite is known to lower the translucency of bodies. This type of body, therefore, is adaptable only to ware in which translucency is not a factor.

III. Conclusions

In studying the foregoing data, it should be remembered that although the tests were made under carefully controlled laboratory conditions the actual figures may not check closely with those obtained under factory conditions. The same general effect of HS pyrophyllite, however, should occur.

[2] P. F. Kerr, "A Pinitized Tuff of Ceramic Importance," *Jour. Amer. Ceram. Soc.*, **23** [3] 65–71 (1940).

TABLE VII

HS PYROPHYLLITE IN VITREOUS CHINA BODIES

Body No.	Composition (%) 30	31	32	33	34
Jasper flint	37.0	32.0	27.0	22.0	17.0
Maine feldspar	17.0	17.0	17.0	17.0	17.0
M. & M. English china clay	16.0	16.0	16.0	16.0	16.0
Lunday N. C. kaolin	10.0	10.0	10.0	10.0	10.0
Ky.-Tenn. Clay Co. No. 4 ball clay	9.0	9.0	9.0	9.0	9.0
Edgar EPK Fla. kaolin	8.0	8.0	8.0	8.0	8.0
U. S. G. Conn. dolomite	3.0	3.0	3.0	3.0	3.0
Calcined HS Pyrax pyrophyllite		5.0	10.0	15.0	20.0

Cone No.	Absorption of dry weight (%)				
5	11.3	11.1	11.7	11.1	11.5
7	1.5	1.2	1.4	1.2	1.2
8	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0

Cone No.	Body No.	Total shrinkage of green length (%) 30	31	32	33	34
5		8.7	8.7	8.3	8.3	9.0
7		12.6	12.6	12.7	12.5	12.4
8		12.7	12.6	13.0	13.1	13.3
9		13.0	13.0	13.3	13.6	13.6
11		13.3	13.0	13.5	13.7	13.7
12		12.7	13.0	13.0	13.0	13.7
		Translucency (cm.)				
12		0.94	0.83	0.78	0.75	0.71
		Modulus of rupture (lb./sq. in.)				
9–10		7080	8150	8650	8770	8930
		Strength increase (%)				
9–10			15.1	22.2	23.8	26.2

(1) The substitution of a high sericite pyrophyllite for the flint in vitreous bodies materially increases the fired strength.

(2) When a high sericite pyrophyllite is substituted for all of the flint and from 2 to 6% of the feldspar content of vitreous bodies, there is a further increase in the fired strength except in the case of the sanitary-ware bodies (in this study).

(3) This substitution has little or no effect on the shrinkage or absorption of the bodies.

(4) The increased strength is probably caused by the formation of mullite with its resulting interlocking grain structure.

(5) The calcining of HS pyrophyllite does not take away any of its advantages, but it does permit its use in jiggered bodies.

Acknowledgment

The author wishes to express his appreciation to Ira E. Sproat and C. C. Treischel of the R. T. Vanderbilt Company for their valuable suggestions and cooperation in connection with this research and to Paul F. Kerr, Department of Geology, Columbia University, for his X-ray and petrographic analyses of pyrophyllite samples.

THE R. T. VANDERBILT COMPANY, INCORPORATED
230 PARK AVENUE
NEW YORK, N. Y.

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

Ross C. PURDY, Editor

ABSTRACTERS

J. B. Austin	P. S. Dear	P. G. Herold	W. D. Klugman	E. C. Pierce	H. E. Simpson
A. A. Ayars	Frank Fisher	W. H. Herschel	Yosio Kora	Alexis Pineus	A. P. Sorn
L. R. Barrett	W. D. Foster	M. B. Hill	R. Kunin	M. E. Poor	F. E. Sonnenschein
K. W. W. Bartlett	J. L. Gallup	F. J. Hurlbut	B. B. Lane	Katherine Reed	A. G. Stern
A. C. Bevan	J. D. Gat	G. M. Hutt	C. H. Lemke	H. K. Richardson	B. H. Strom
D. A. Biddle	R. A. Gregory	J. F. Hyde	W. Loewenthal	R. A. Ronnebeck	M. Takei
A. Biddulph	Robert Halle	Herbert Insley	F. S. Mallette	B. C. Ruprecht	L. E. Thiess
P. P. Budnikov	Max Hartenheim	C. B. Jenni	V. S. de Marchi	A. B. Searle	Hans Thurnauer
J. C. Chaston	J. J. Hazel	B. Z. Kamich	L. F. May	J. P. Shanok	E. J. Vachuska
W. M. Cohn	F. G. Heck	B. B. Kinkulkin	E. H. McClelland	Lucille Shattuck	F. J. Zvanut
M. V. Condoid	R. A. Heindl	G. A. Kirkendale	J. M. Noy	G. R. Shelton	

JOURNAL REFERENCE: The journal name appears in italics, followed by the volume (bold-faced), issue number (in brackets), page numbers, and year (in parentheses).

April, 1941
20—4

Abrasives

Abrasives and grinding. LOWELL H. MILLIGAN. *Bull. Amer. Ceram. Soc.*, 20 [2] 39–47 (1941).—13 references.

Cutting tools important in rearmament program. ANON. *Mill & Factory*, 27 [4] 32 (1940).—Cutting tools of cemented carbides will play an important part in America's rearmament. D.A.B.

Loose-abrasive finishing. H. W. FAINT. *Monthly Rev. Amer. Electroplaters' Soc.*, 27, 449–50 (1940).—The term "finishing" is limited to the development of a lustrous surface on steel and stainless steel. Loose abrasives include emery, aluminum oxide, and silicon carbide. The process involves (1) relatively slow speed (1500 to 2500 ft. per min.) muslin wheels, (2) loose abrasives with lubricants, and (3) high pressure of surface to be finished against the wheel. Pressures of approximately 200 lb. per sq. in. are obtained by the use of appropriate pneumatic equipment. The action is considered to be largely plastic flow rather than abrasion. The finish is equal to that of the best burnished surfaces. The burning or bluing of stainless steel encountered with setup wheels is eliminated. C.H.L.

Open-hearth problems. T. W. LIPPERT. *Iron Age*, 143 [18] 53–58, 78–80 (1939).—L. gives a review of a meeting of the Open-Hearth Committee of the American Institute of Mining and Metallurgical Engineers. Brief abstracts of the papers on refractories are included. E.H.McC.

Possibility of using synthetic abrasives for fine-polishing of optical glass. N. B. MOSKVIN. *Optiko Mekh. Prom.*, 10 [6–7] 23–24 (1940).—Attempts to use synthetic abrasives for polishing optical glass have been successful. M.V.C.

Thin abrasive wheel as a production tool. F. A. UPPER. *Mill & Factory*, 26 [4] 82–84 (1940).—Thin abrasive wheels having a thickness of $^1/_{32}$ to $^1/_8$ in. have many industrial uses in cutting off material, slitting, slotting, and grooving. They are used in cutting both hard and tough steels, rods, tubes, plastics, glass brick, tile, stone, porcelain, carbon, slate, rubber, etc. (0.005-in. wheels are used for cutting slots in pens). Abrasive wheels are advantageous in that smooth parallel surfaces which require no further treatment are produced rapidly. Typical cutting data are given which take into consideration the following factors: material, number of cuts per wheel, time per cut, dry or wet cutting, high-speed wheels and effects on wheels, abrasive-wheel recommendations, types of abrasive used in wheels, and their bonds. D.A.B.

PATENTS

Abrasive article. W. J. TENNANT (Carborundum Co.). Brit. 530,330, Dec. 26, 1940 (June 9, 1939).

Abrasive article and method of making. H. V. ALLISON (Allison Co.). U. S. 2,229,880, Jan. 28, 1941 (Jan. 25, 1940).

Abrasive materials. CUTANIT, LTD. Brit. 531,077, Jan. 8, 1941 (May 27, 1938).

Abrasive wheel dressers. J. H. STRINGFELLOW. Brit. 531,111, Jan. 8, 1941 (July 12, 1939).

Apparatus for grinding knife blades. VICTOR FRIEDRICH. Ger. 683,611, Oct. 19, 1939 (Aug. 20, 1935); XII/67*c*. 4.—The knife blade is moved in a ridge made in the base of the apparatus so that the grinding angle will be constant. The blade contacts the middle of a long fixed grinding surface. D.A.B.

Apparatus for grinding and polishing gems. FRANZ FEIX. Ger. 684,913, Nov. 16, 1939 (Jan. 20, 1938); XII/67*a*. 21.—A machine for grinding and polishing gems, especially their facets, is described. D.A.B.

Axially slidable supporting means for grinding wheels. C. G. EKHOLM (Lidköpings Mekaniska Verkstads Aktiebolag). U. S. 2,229,281, Jan. 21, 1941 (Oct. 11, 1939).

Blade-grinding machine. H. J. CRINER (A. G. Bush). U. S. 2,229,918, Jan. 28, 1941 (May 3, 1939).

Brake shoe dresser. H. K. BIGELOW (B. S. Lurie). U. S. 2,230,824, Feb. 4, 1941 (May 8, 1939).

Cambering mechanism for grinding machines. CINCINNATI GRINDERS, INC. Brit. 531,735, Jan. 22, 1941 (Nov. 7, 1938).

Crankshaft lapping machine. NORTON CO. Brit. 531,128, Jan. 8, 1941 (July 20, 1938).

Cylinder ridge grinder. GUSTAV SOLBRIG (William H. Dutton). U. S. 2,229,314, Jan. 21, 1941 (Feb. 12, 1940).

Device for trimming the rounded edges of grinding wheels and chiefly for machines used for grinding gear wheels. W. C. FAIRWEATHER (Soc. Française d'Engrenages à Denture Rectifiée). Brit. 531,013, Jan. 8, 1941 (July 8, 1939).

Fastening device on small electric machines, e.g., grinding machines. ROBERT BOSCH G.M.B.H. Ger. 687,831, Jan. 18, 1940 (Feb. 29, 1932); XII/67*a*. 31.02. D.A.B.

Fully automatic cylindrical grinding machine. H. A. SILVEN AND D. W. STEPHENSON (Norton Co.). U. S. 2,229,312, Jan. 21, 1941 (June 1, 1939; Oct. 20, 1939).

Gear-grinding machines. GEAR GRINDING CO., LTD., AND A. H. ORCUTT. Brit. 531,443, Jan. 15, 1941 (July 22, 1939).

Grinding or abrading machines. W. T. SCHAURTE. Brit. 530,716, Jan. 1, 1941 (July 25, 1938). A. H. STEVENS (Boyar-Schultz Corp.). Brit. 529,744, Dec. 18, 1940 (June 6, 1939).

Grinding apparatus. M. H. JOHANSON (Gleason Works). U. S. 2,231,762, Feb. 11, 1941 (Aug. 24, 1938).—Apparatus for grinding convex rounds on the blades of a face-mill gear cutter.

Grinding apparatus for the sickle or crescent blades in cigarette-making machines. HENRY THOMSSEN (H. F. & F. Reemtsma). Ger. 687,783, Jan. 11, 1940 (Sept. 5, 1938); III/79*b*. 19.50. D.A.B.

Grinding machine. J. O. DEVAU. U. S. 2,229,374, Jan. 21, 1941 (Feb. 2, 1939).

Grinding or sharpening machines for knives and other cutting tools. J. R. BROWN. Brit. 530,625, Jan. 1, 1941 (June 14, 1939).

Grinding or sharpening wheels. J. R. BROWN. Brit. 530,670, Jan. 1, 1941 (July 15, 1939).

Grinding two-plane inclined contact surfaces on used railroad wheels. EWALD HANUS. Ger. 680,387, Aug. 3, 1939 (Aug. 3, 1935); XII/67*a*. 10.—When the grinders are operating, the carriers of the grinding wheels revolve around a point lying in the center of a circle which passes through three points determined by the two-plane inclinations of the contact or running surfaces of the wheel. The grinding wheel, after being given the necessary preliminary dressing, is swung on its carrier opposite the edge of the railroad wheel in such a manner that the effective surface of the grinding wheel lies parallel to the inclination being ground. The grinding wheel is adjusted for each grinding. D.A.B.

Honing or lapping machines. A. F. BURGESS (Barnes Drill Co.). Brit. 531,537, Jan. 15, 1941 (Sept. 19, 1939).

Honing methods and devices. MICROMATIC HONE CORP. Brit. 529,681, Dec. 18, 1940 (Feb. 23, 1939).

Lapping apparatus. D. A. WALLACE (Chrysler Corp.). U. S. 2,229,318, Jan. 21, 1941 (July 16, 1938).

Lapping machine. W. H. WOOD (Norton Co.). U. S. 2,230,921, Feb. 4, 1941 (Aug. 17, 1940).

Machine for grinding injection needles. H. ENYA. Brit. 530,737, Jan. 1, 1941 (June 29, 1939).

Machine for grinding rolled millings. W. FERD. KLINGELNBERG SÖHNE. Ger. 683,514, Oct. 19, 1939 (Oct. 28, 1935); XII/67*a*. 1.—A machine for grinding rolled millings is provided with the workpiece carrier and the tool carrier fixed on a cylindrical shaft and capable of being tilted in reference to each other. The shaft serves as a guide, and the tilting movement is produced by a movable supporting medium. One of the bushings is constructed as a hydraulic cylinder to produce the tilting and guiding of the tool carrier. D.A.B.

Machine for grinding or sharpening knives, etc. P. STANLEY. Brit. 531,771, Jan. 22, 1941 (Aug. 1, 1939).

Machine for grinding the threads of thread-cutting tools. SOC. GENEVOISE D'INSTRUMENTS DE PHYSIQUE. Brit. 530,594, Dec. 26, 1940 (July 18, 1938).

Machine for grinding tool bits. E. C. OLIVER. U. S. 2,231,217, Feb. 11, 1941 (Feb. 6, 1939).

Making rubber-bonded abrasive articles. H. V. ALLISON (Allison Co.). U. S. 2,229,879, Jan. 28, 1941 (Dec. 15, 1939).

Portable power-driven grinding tool. W. W. NASH (Independent Pneumatic Tool Co.). U. S. 2,229,598, Jan. 21, 1941 (Jan. 2, 1940).

Profile truing template for grinding machines, etc. C. G. EKHOLM AND B. D. O. WESTERLUND (Lidköpings Mekaniska Verkstads Aktiebolag). U. S. 2,229,280, Jan. 21, 1941 (Aug. 10, 1939).

Saw sharpener. A. C. ELDER. U. S. 2,229,644, Jan. 28, 1941 (Sept. 1, 1937).

Silicon carbide manufacture. R. C. BENNER, R. L. MELTON, AND J. A. BOYER (Carborundum Co.). Can. 393,060, Dec. 10, 1940 (Aug. 3, 1939). G.M.H.

Truing templates for grinding, lapping, and polishing machines. LIDKÖPINGS MEKANISKA VERKSTADS AKTIEBOLAG. Brit. 531,485, Jan. 15, 1941 (Aug. 13, 1938).

Vertical grinding machines. WRIGHT ELECTRIC MOTORS (Halifax), LTD., AND H. H. WRIGHT. Brit. 531,584, Jan. 22, 1941 (July 27, 1939).

Art and Archeology

Artist-designers sought by Federal Government. ANON. *Bull. Amer. Ceram. Soc.*, **20** [2] 74 (1941).

Baltimore potters' round table. MILDRED L. CLEGG. *Bull. Amer. Ceram. Soc.*, **20** [2] 75–76 (1941).

Ceramic Guild of Cincinnati. ANON. *Bull. Amer. Ceram. Soc.*, **20** [2] 74 (1941).

Color psychology, its place in product design. D. L. HADLEY. *Product Eng.*, **12** [2] 81–84 (1941).—The value of selecting proper color and color contrasts to enhance the appearance of machinery, apparatus, and finished products and thus increase their selling value is emphasized. Examples show the application of the principles involved for power-station machinery, devices for daily use, and appliances. Line and shape are also important, and both can be affected favorably by color contrasts. M.H.

Early history of Staffordshire pottery. G. J. V. BEMROSE. *Trans. North Staffordshire Field Club*, **74**, 65 (1940); *Trans. Brit. Ceram. Soc.*, **39** [10] 100A (1940).—B. describes the results of two excavations in Burslem which confirm the conclusion of previous writers in tracing the history of Staffordshire pottery to the butter pot. The finds included large fragments of 17th century tygs and pieces of so-called "Littler blue" salt-glazed ware and "scratch blue." Below the tygs were large fragments of unglazed butter pots. The tygs were of a form unusual in Staffordshire pottery, and the glaze was of a deep brown color, quite distinct from the usual black. On another site a rich vein of typical middle 18th-century pottery was found, including both plain and molded slip and slip molds. These rendered it possible to identify a hitherto unknown Staffordshire slipware potter; molded and notched slip dishes with biblical inscriptions in relief, known as S.M. dishes, have been allocated with some certainty to Samuel Malkin, parish clerk of Burslem (1668 to 1741). An early map of Burslem (1720) shows the location of the Malkin works.

Further technological notes on the pottery of the Younge site, Lapeer County, Michigan. FREDERICK R. MATSON, JR. *Papers Mich. Acad. Science, Arts & Letters*, **24** [Part IV] 11–23 (1938).—The previous study of the pottery found by E. F. Greenman (*Ceram. Abs.*, **17** [6] 211 (1938)) mentioned only briefly the experiments on firing shrinkage. The average shrinkage curves and color changes in the clay at different temperatures indicated an original firing temperature of about 600°C. A more recent restudy of the firing data shows altered conclusions. Average shrinkage curves were plotted for sherds of the pottery fired to 950°C. and compared with similar curves charted for briquettes of natural clay fired to 1100°, levi-

gated clay fired to 980°, 75% natural clay and 25% crushed granite fired to 1000°, and 75% levigated clay and 25% crushed granite fired to 1145°. All of the curves have three phases: low-temperature shrinkage, expansion, and rapid shrinkage. The shrinkage of the sherds below 500° is due, probably, to rehydration of the clay during long burial in moist earth. The briquettes showed a slight dehydration shrinkage between 400° and 500°. In the expansion range 450° to 900°, where α-β quartz inversion takes place and leaves small stress cracks in the clay, the natural sandy clay briquettes showed less expansion than the levigated clay because the grains of sand in the former resisted the formation and development of the cracks. The sherds showed only a slight expansion in comparison with the briquettes; this is attributable to the fact that they had already been fired to at least 573° and cracks were already there to absorb the initial stress of the quartz inversion. Above 800°C. most of the sherds and clay briquettes began to shrink rapidly, indicating that the sherds had not previously been fired above 800° and that the clay used in the synthetic study is essentially similar to that used by the Indians. Although the many conditioning factors affecting shrinkage and expansion are not fully considered, the subtraction method, in which the percentage of maximum expansion of the averaged sherds is subtracted from that of each of the control briquettes to determine the temperature of expansion, indicates that the sherds had a maximum firing temperature of about 750°. Experiments with clay fired at temperatures up to 550°C., in which the residual plasticity and color and water slaking properties and color comparisons were studied, showed a possible temperature range for the firing of the pottery of 500° to 740°. Such determination of the firing temperatures of pottery should be of significance to archeologists in further study of the technological cultures of the American Indians. M.E.P.

Glass: artist, designer, artisan. ALEXANDER SILVERMAN. *Glass Ind.*, **21** [7] 316–22 (1940).—S. appraises the Steuben Glass, Inc., project of reproducing twenty-seven engravings on crystal from designs by contemporary artists. Each piece is illustrated. See "Painters . . .," *Ceram. Abs.*, **19** [4] 85 (1940). A.P.

Glass vases. BRUNO MAUDER. *Glashütte*, **70** [45] 585–88 (1940).—The glass vase may be purely ornamental or also utilitarian. Flower vases must have a shape suitable to the flower form, and rich ornamentation is superfluous; any decoration should follow the form of the vase. Light colors are popular, and colorless crystal is also being used. Certain standard forms of glass vases must be adhered to in mass production because fantastic shapes are too soon outmoded. Outline drawings of eight established styles and their variations are given: (1) the simplest one-piece forms with stable bases and wide mouths, (2) the one-piece bellied form made with the simplest technique and suitable for large flowers, which is very stable because the weight of the water lies in the lower part of the vase, (3) vases with long narrow necks, used more for decoration and long-stemmed flowers, (4) vases with a short blown foot, primarily utilitarian, (5) vases with a separately attached wide foot which gives solidity in spite of the upward and outward curve of the sides and the wide mouths (these are made in two operations), (6) purely ornamental vases, which may also be used for a bud or two, having a tall well-proportioned curved form with a foot and often a stem, (7) ornamental art forms, seldom used for flowers, having a bell-shaped top, a grooved intermediate knob, and a short open bell base, and (8) the large hand-worked jar form, which is more of a show piece; its sides are ribbed, while the attached base may or may not be notched. M.V.C.

Grecian glass, a modernized antique. ALEXANDER SILVERMAN. *Glass Ind.*, **21** [1] 22–23 (1940).—The Société Anonyme Hellenique de Produits et Engrais Chimiques has a division which produces antique glass of artistic excellence. 4 photographs. A.P.

Kington Baker bequest. R. S. JENYNS. *Brit. Museum Quart.*, **14** [3] 53 (1940).—Six pieces of Kakiemon and a fine range of Nabeshima ware (all early 18th century Japanese porcelain) are briefly described with some notes on Kakiemon ware in general. A Kakiemon bowl and tray are illustrated. A.B.S.

Localization of the pottery industry. A. B. HOLLOWOOD. *Trans. North Staffordshire Field Club*, **74**, 22 (1940); *Trans. Brit. Ceram. Soc.*, **39** [10] 100A (1940).—The following factors favored the expansion of the pottery craft in the upper Trent valley: (1) availability of all raw materials needed for the production of crude earthenware, e.g., clays, marls, grits, and superficial deposits of fine glacial material; (2) an abundant coal supply of a quality specially suited to pottery firing; and (3) the presence within easy reach of other raw materials such as lead ore at Lawton Park and salt in Cheshire. The comparative poverty of the region agriculturally and its isolation favored the development of pottery making as a side line, mainly by small holders. Inadequate transport facilities permitted the pottery industry to maintain and increase its importance, while others, e.g., the iron industry, although favored by excellent ore deposits, made very slow progress until after 1850. The Grand Trunk Canal (1777) saved the pottery industry when new raw materials were introduced from Cornwall and Dorset. In other districts, e.g., Leeds, Liverpool, Derby, Bristol, etc., industrialists were attracted by the larger returns from the shipbuilding, cotton, wool, iron, and steel industries. By its very nature, the pottery industry cannot be completely mechanized, and mass production methods cannot be applied. Thus the industry enjoyed none of the spectacular profits which were common in the early stages of the industrial revolution.

Pottery and glassware trade in Britain. ANON. *Manchester Guardian Commercial*, **37** [967] 609 (1938).—The use of good ornamental pottery and glassware has declined because of the severity of modern furniture design. F.J.H.

Roman glassmakers' art in Germanic provinces. W. GANZENMÜLLER. *Glashütte*, **70** [38] 497–500 (1940).—The history of glassmaking in England, France, and Germany begins with the time of the Romans. The encampments of the Roman Legions in these provinces grew into towns which furnished the supplies the soldiers were accustomed to at home. Hollow glassware for daily use was so much in demand that glass plants were built. The difficult art of glass blowing was introduced in Rome by workers and merchants from Syria and spread from there to the provinces. A description is given of the excavation at Wilderspool near the Mersey, England, of a glassworks built during the time of the Roman Caesars. Ordinary green glass and finer kinds of colorless glass were made in the Roman provinces. Lead was used for colorless glassware. Pliny describes how glass was made in the 1st century A.D.: Sand was mixed with a large amount of soda (Egyptian crude soda containing 22.4% pure soda, 18.3% sodium sulfate, and 38.6% common salt, according to von Klaproth) to assure a low softening point because wood was used as fuel. Lime; pyrolusite (whose coloring and decoloring properties were known); FeO for black coloring; Fe_2O_3 for green, yellow, blue, and black; copper oxide (CuO) for green, blue, and black; Cu_2O for red; and tin oxide for opaque white were used in Roman glass. Panes of window glass have been found in Roman villas in Germany. They were not first blown and then flattened but were made by pouring the glass mass on a slab and drawing it out on all sides with pincers, with the result that the center was much thinner than the edges. Panes from Saalburg measured 30 x 60 cm. and were 2 mm. thick in the center and 5 mm. thick at the edges. The glass was sometimes roughened on one side and therefore not entirely transparent, although transparent glass has also been found. Mirrors were also made of this poured glass by Rhenish glassworkers. All kinds of hollow glassware, from the cheapest to the most valuable, were produced. The Syrian glassmakers brought their skill in decorating glass to Cologne. In one variety of decoration glass threads were imposed by hand on a hot surface in spirals, zigzags, networks, rosettes, and even inscriptions. By using three blowpipes simultaneously, objects of sev-

eral parts were made; small objects were placed inside of large objects. Examples of remarkable works are shown, including a vase in which large holes were cut in the sides while soft and the glass was fashioned into four hollow pillars, leaving a rectangular open space in the center in which a small glass urn was inserted. Another flask has four holes in the walls in the form of a cross with opaque white doves placed within the openings. In the 3d and 4th centuries, Rhenish glassmakers reached their highest development in antique glass cutting and engraving. The "net goblet," which was unbelievably difficult to make, comprised a rather thick bell-formed glass on which the net pattern was sketched and then cut out and away from the goblet, only small cross pieces being left to attach it to the goblet. It required half a year to reproduce such a goblet for the Nürnberg Exhibition in 1884. In the making of gold glasses, the Rhenish glassmakers surpassed the Italian. Different techniques are mentioned. The belief is expressed that the barbaric Germanic tribes did not destroy the culture of the Romans but rather built upon it and made certain contributions of their own.
M.V.C.

Roman mold-blown glasses. D. B. HARDEN. *Connoisseur*, **106** [469] 102–105 (1940).—Glass was first blown into molds of clay in Syrian glasshouses in the 1st century A.D. Because they signed their ware, four of the artists are known: Ennion, Jason, Meges, and Neikaios. Ennion, probably the inventor, was the greatest. He established a branch of his factory in northern Italy, probably near Aquileia or Venice. By the middle of the 2d century a new style of mold-blown vases was made, like sculpture, in the round, in the shape of human heads or bunches of grapes or dates. The Roman glasshouses produced the famous mold-blown chariot and gladiator cups which have been found on many sites in Gaul, Switzerland, Germany, Spain, and Britain. They are small cups, normally cylindrical, of thin green, dark blue, or amber glass, upon which are mold-blown friezes depicting chariot races, etc. These "picture cups" were a short-lived vogue, but mold-blowing continued to spread throughout France and into the Rhineland in the early 2d century. The art never equaled the work of Ennion and his contemporaries in Syria and Italy. Illustrated.
M.E.P.

Technological study of the glass from the Corinth factory. FREDERICK R. MATSON, JR. *Amer. Jour. Archaeology*, **44** [3] 325–27 (1940).—A study of 22 samples of 11th- to 12th-century glass produced at the Agora South Central glass factory at Corinth indicates no major change in Mediterranean world colors for over 1000 years. The Corinth glass is more similar to Egyptian and Roman ware than to Islamic on the basis of softening temperatures, but lack of surface decay shows an improvement in composition since Roman times. A table shows the properties of the various samples, including color, index of refraction, relative composition, and softening point.
M.E.P.

Vincennes porcelain clock case. W. KING. *Brit. Museum Quart.*, **14** [3] 54–56 (1940).—A brief description is given of a clock case made at Vincennes of unglazed porcelain of the kind invented by Bachelier in 1751. Illustrated. See "Porcelain. . .," *Ceram. Abs.*, **17** [7] 243 (1938).
A.B.S.

BOOKS

Early Muslim Architecture, Umayyads, Early Abbasides, and Tulunids: II, A.D. 791–905. K. A. C. CRESWELL. Oxford University Press (Clarendon Press, Humphrey Milford), London. 123 plates, 261 line and halftone illustrations. Price £10 10s. Reviewed in *Times Lit. Supp.*, **39** [2022] 558 (1940).—Every known Muslim building of the period in Europe, Asia, and Africa is described and illustrated. Of particular interest from the ceramic viewpoint is the change in building materials from cut stone to brick and stucco coincident with the fall of the Umayyad dynasty and the transfer of the seat of the Khalifat from Damascus to Baghdad. This volume contains a summary, a chronology, and an index. For Vol. I see *Ceram. Abs.*, **11** [11] 580 (1932).
K.W.W.B.

Iberians of Spain and Their Relations with the Aegean World. PIERSON DIXON. Oxford University Press (Humphrey Milford), London. Price 8s 6d. Reviewed in *Times Lit. Supp.*, **39** [2022] 559 (1940).—D. sketches the history of the Iberians from the time of the Phoenicians to that of the Roman control and discusses the characteristic art forms of Iberian civilization. Vase painting, sculpture, bronze figurines and jewelry, and architecture are dealt with. The inspiration derived from the Greek influence is contrasted with the repressive effects of Rome and Carthage.
K.W.W.B.

Studies and Documents: Vol. XIII, Archaeological Record of Rome from the Seventh to the Second Century B.C. INEZ SCOTT RYBERG. University of Pennsylvania Press, Philadelphia; Christophers, London. Two parts. Price 35s. Reviewed in *Times Lit. Supp.*, **39** [2018] 511 (1940).—R. attempts to present within reasonable compass a conspectus of the surviving remains of pottery, terra-cotta arulae, etc., recovered by archeologists and others in or in relation to Rome. She discusses the Etruscan period (7th to 6th century B.C.), the decline of Rome which followed, the later Necropolis (4th to 1st century B.C.), and the industrial activity and commercial relations of the 4th and 3d centuries B.C., with additional chapters on terra-cotta arulae and terra-cotta architectural decoration. The first volume contains the text, the illustrations being printed separately in the second part together with a reference map from Kiepert.
K.W.W.B.

Wisdom of the Egyptians: Vol. LXIII. W. M. FLINDERS-PETRIE. Hazell, Watson and Viney. Price 10s 6d. Reviewed in *Times Lit. Supp.*, **39** [2029] 647 (1940).—The acquired knowledge and skill in the various branches of civilization which have been elaborated by the successive dwellers in the Nile Valley are surveyed. The elements of science as practiced by the Egyptians are classified and examined, including drawing and design, building, mineralogy and chemistry, metal working, and pottery. Illustrated.
K.W.W.B.

PATENTS

Coating vitreous surfaces with luminescent materials. GENERAL ELECTRIC CO., LTD., L. F. BRITTEN, H. G. JENKINS, AND A. H. MCKEAG. Brit. 530,531, Dec. 26, 1940 (June 19, 1939).

Color chart. A. H. KEYES. U. S. 2,229,025, Jan. 21, 1941 (April 29, 1939).

Designs for:

Ash tray. C. R. KEERAN (Illinois Stamping & Mfg. Co.). U. S. 124,858, Jan. 28, 1941 (May 6, 1940).

Bottle. P. I. HEUISLER, JR. (Maryland Glass Corp.). U. S. 124,920, Jan. 28, 1941 (Nov. 23, 1940). H. D. JERSIG. U. S. 124,742, Jan. 21, 1941 (May 18, 1940). W. R. LEACH, JR. (Carr-Lowrey Glass Co.). U. S. 124,861, Jan. 28, 1941 (Nov. 27, 1940). P. G. LLOYD (Carr-Lowrey Glass Co.). U. S. 124,748, Jan. 21, 1941 (Nov. 20, 1940). FRANK MCINTOSH (Lentheric, Inc.). U. S. 124,749, Jan. 21, 1941 (Oct. 24, 1940). FRANK MCLAUGHLIN (Carr-Lowrey Glass Co.). U. S. 124,865, Jan. 28, 1941 (Nov. 27, 1940). O. C. NOBLE (Tygart Valley Glass Co.). U. S. 124,939, Jan. 28, 1941 (Aug. 3, 1940).

Bottle. ST. WILLIAMS PRESERVERS, LTD. Can. 12,910, Dec. 14, 1940.
G.M.H.

Covered bowl. J. R. THOMPSON (Hall China Co.). U. S. 124,881, Jan. 28, 1941 (Sept. 23, 1940).

Glass ash tray. A. J. DREITZER (Pitman-Dreitzer & Co., Inc.). U. S. 124,739, Jan. 21, 1941 (Nov. 25, 1940).

Glass nappy. BELLE KOGAN AND A. H. NICHOLSON (Federal Glass Co.). U. S. 124,859, Jan. 28, 1941 (Nov. 25, 1940). A. H. NICHOLSON (Federal Glass Co.). U. S. 124,870, Jan. 28, 1941 (Nov. 25, 1940).

Goblet. A. J. CUNNINGHAM. U. S. 124,736 to 124,738, Jan. 21, 1941 (June 3, 1940). U. S. 125,065 to 125,082, Feb. 11, 1941 (June 3, 1940).

Jug. FRANK MCLAUGHLIN (Carr-Lowrey Glass Co.). U. S. 124,864, Jan. 28, 1941 (Nov. 27, 1940).

Lighting-fixture bowl. C. F. HAAS AND F. C. WINKLER (Westinghouse Electric & Mfg. Co.). U. S. 125,135, Feb. 11, 1941 (June 1, 1940).

Molded glass article. G. E. REINER (Canadian General Electric Co., Ltd.). Can. 393,333, Dec. 24, 1940 (July 12, 1938). G.M.H.

Multicolor printing machine for glass, metal, etc. FREDERICK SHURLEY (Guthrie Ceramic Labelling & Machinery Co., Inc.). U. S. 2,229,346, Jan. 21, 1941 (April 27, 1938).

Registering device for multicolor printing. FREDERICK SHURLEY (Guthrie Ceramic Labelling & Machinery Co., Inc.). U. S. 2,229,347, Jan. 21, 1941 (Feb. 14, 1939).

Tile shape. J. H. ISENHOUR. Can. 393,299, Dec. 24, 1940 (May 25, 1940). G.M.H.

Cements

Constitution of Portland cement clinker. R. H. BOGUE. *Cement & Lime Manuf.*, **13** [1] 3–11 (1940).—Expansions of cement specimens due to free CaO and to periclase may be differentiated, and a method is suggested which may be useful in ascertaining the ultimate sources of expansion characteristics. The influence of $3CaO \cdot Al_2O_3$ on the autoclave expansion is indicated by data obtained in a study of the effects of the heat-treatment of commercial clinkers on the properties of the cement. Rapidly cooled cement clinkers, containing more glass than slowly cooled clinkers, show consistently higher heats of hydration. Equations for calculating the phase composition of clinker with normal crystallization to an estimated glass content are given in an appendix. G.R.S.

Effect of heat-treatment and cooling rate on the microscopic structure of Portland cement clinker. GEORGE W. WARD. *Jour. Research Nat. Bur. Standards*, **26** [1] 49–64 (1941). Price 10¢.—Ten commercial Portland cement clinkers with their slowly and quickly cooled counterparts were examined microscopically. Methods for conducting the microscopical examination are given. The appearance of the clinker phase after the different heat-treatments is described, and the structure of the clinkers is discussed. In general, for all clinkers, the phase compositions as calculated with consideration of glass agreed better with the microscopically determined phases than did those based upon the calculations in which complete equilibrium crystallization was assumed. The microscopically determined $3CaO \cdot SiO_2$ was almost always greater and the $2CaO \cdot SiO_2$ lower than those calculated by either of the other methods. The $3CaO \cdot Al_2O_3$ was always less than that calculated from chemical analyses. Generally, the $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ found microscopically exceeded that calculated by either of the other methods. The glass determined microscopically and the values obtained from the heat of solution method agreed better for slowly cooled and plant-cooled clinkers than for quickly cooled clinkers. R.A.H.

Hydrothermal and X-ray studies of the garnet-hydrogarnet series and the relationship of the series to hydration products of Portland cement. E. P. FLINT, HOWARD F. MCMURDIE, AND LANSING S. WELLS. *Jour. Research Nat. Bur. Standards*, **26** [1] 13–33 (1941); RP 1355. Price 10¢.—Isometric tricalcium aluminate hexahydrate, one of the well-established products of hydration of Portland cement, forms complete solid solutions with the corresponding ferrite, $3CaO \cdot Fe_2O_3 \cdot 6H_2O$, with grossularite garnet, $3CaO \cdot Al_2O_3 \cdot 3SiO_2$, and with andradite garnet, $3CaO \cdot Fe_2O_3 \cdot 3SiO_2$. Members of the solid-solution series were synthesized by hydrothermal methods, and X-ray determinations were made of their crystal structures. To the series belong (1) the mineral plazolite, $3CaO \cdot Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, (2) the major product of hydration of the glass phase in Portland cement clinker at elevated temperatures and pressures, and (3) one of the major products of hydration of tetracalcium aluminoferrite. R.A.H.

Enamel

Acid-resisting enamels. PAUL WEISSNER. *Chem.-Ztg.*, **63** [72–73] 617 (1939).—The use of acid-resisting enamels, especially in apparatus construction, not only introduces a saving but protects the charge in the apparatus from metallic influences. The glass enamel is fired on cast iron at 1000°C. in several steps, and the composition can be so fixed that a very resistant enamel results. This type of enamel is suitable for cosmetic and pharmaceutical manufacture. Another acid- and heat-resistant enamel is applied to sheet metal and cast steel at 1100°C.; it adheres readily to these metals. A bright-gray enamel is suitable as a coating for cast iron, and a blue-green enamel is made for sheet metal. Both of these colored enamels are resistant to organic and inorganic acids with the exception of HF. A dark-blue enamel is resistant to fatty acids, lacquers, and oils. An elastic silicon enamel is suitable where heat changes are involved. There are also enamels suitable for vacuum processes. D.A.B.

Analytical treatment of enamels and their raw materials. E. O. PRIMBSCH. *Emailwaren-Ind.*, **17** [37–38] 97–99 (1940).—Most raw materials for enamels are natural products and therefore have a fluctuating composition and contain impurities. Certain impurities have little or no effect on the enamel in quantities as high as 0.1% or more, but the composition of the raw materials must be determined. Analytical chemistry has not dealt extensively with tests for enamel raw materials; exact testing methods exist, but they are too elaborate or unsuited for practical application in industry. A method for feldspar analysis which has been worked out in practice and approved is given. This analysis is of great importance because feldspar forms a large part of many batches and varies considerably in composition. Its SiO_2, Al_2O_3, and alkali contents must be determined because these materials have a decisive influence on the properties of enamels. Impurities are Fe, Ti, Ca, Mg, and perhaps Ba; their total should not exceed 2 to 2.5%. The analysis is divided into (1) the soda treatment, to determine the SiO_2 content, and (2) the acid treatment with HF and H_2SO_4, to determine the Al_2O_3 and alkali contents. (1) In the soda treatment 0.5 gm. is used. All metal oxides are converted into carbonates, and SiO_2 is converted into sodium silicate in a platinum crucible in the usual way. The crucible is cooled in cold water, and the melted pieces are placed in a flat-bottomed porcelain dish 12 cm. in diameter; hot water is added, and the mixture is stirred with a glass rod until the disappearance of all lumps. The dish is almost completely covered with a watch glass, and concentrated HCl is added through a small funnel. The platinum crucible is rinsed out with a few drops of concentrated HCl followed by water. The contents of the dish are boiled down, preferably on a water bath. The crystallizing mass must be punched frequently with a glass rod. After the acid is completely expelled by placing the dish briefly on a hot plate, the residue is cooled, moistened with concentrated HCl, and after 10 to 15 min. dissolved in boiling water. Since this separation of SiO_2 is usually not 100% effective, the process is repeated with the filtrate, after the HCl has been added, until the dry residue remains in the dish. This is dried for about 1 hr. in a drier at 120° to 130°. If this were done immediately after the first evaporation, the values would be too high. After drying, the mass is moistened as before with concentrated HCl and diluted with hot water, and the solution is filtered through the same filter. This is washed 6 or 7 times with hot water, ashed in the platinum crucible, and heated to redness.

The crucible is cooled in an exsiccator, its weight is determined, and the contents are mixed with a few cubic centimeters of HF. Concentrated H_2SO_4 (2 to 3 drops) is added carefully, and the mixture is evaporated with great care over a very low flame, the crucible resting on an asbestos wire gauze. The crucible is then heated to redness for a few minutes, cooled, and weighed. The loss in weight by evaporation represents the SiO_2. If a residue of more than 10 mgm. is left, the evaporation must be repeated, but with a correspondingly smaller amount of HF. The residue obtained is aluminum sulfate. (2) The alumina can be determined from the filtrate of the SiO_2. To determine the alkalis and the alumina, 0.3 to 0.5 gm. of the finely powdered feldspar is evaporated in the platinum crucible with 10 cc. of hydrofluoric acid; the evaporation is repeated with the same amount of HF and an addition of 1 cc. of concentrated H_2SO_4. The contents of the crucible must not be dried entirely because a part of the aluminum will be insoluble. After the evaporation, the contents are dissolved out of the crucible with dilute HCl, and the crucible is washed well with hot water. The solution is boiled in a 250-cc. beaker until clear. The clear boiling solution is treated with concentrated ammonia and boiled a few minutes longer. The precipitated aluminum hydroxide balls up and is easy to filter. After settling, it is filtered through a "white band" filter and washed thoroughly with hot water. The filter containing the aluminum hydroxide is dried in a weighed porcelain crucible, ashed, heated to redness, and weighed as Al_2O_3. To determine the alkalis present in the filtrate, it is evaporated to half its volume, treated with about 5 cc. 10% barium chloride solution, and boiled to remove the excess H_2SO_4. A few drops of the solution are poured through a little filter into a reagent glass and tested with some barium chloride to determine whether all the H_2SO_4 is removed. If it is not, barium chloride is added, and the solution is tested until it remains clear. The small samples are always readded to the large amount, and care must be taken that none is lost. When precipitation is completed, 10 gm. of crystallized ammonium carbonate are added without filtering to remove the excess barium, and the mixture is boiled for a few minutes. When the heavy white precipitate has settled, which should occur rapidly, it is filtered. The filtrate contains only the chloride of the alkalis and the ammonium salts. When the precipitate is washed, the filtrate is evaporated in a porcelain dish like that used in the determination of the SiO_2, and the salts obtained are placed in a platinum crucible (or platinum dish, if available). The dried residue is heated to redness gently to destroy the ammonium salts. It changes color, usually to a dark gray, because of the charring of a small amount of organic ingredients. The heating to redness is stopped when no more vapors rise while the platinum crucible is glowing faintly red. The residue now contains only the chlorides of the alkalis, and after the crucible is cooled in the exsiccator, they are weighed. To separate potassium from sodium, the perchlorate method is best; the salt is washed with as little water as possible in a green-glazed flat-bottomed porcelain dish, mixed with about 15 cc. of perchloric acid, and evaporated almost to dryness while being stirred often with a glass pestle. The residue is mixed with 25 cc. of methyl alcohol and pulverized with the glass pestle. Sodium perchlorate dissolves in the alcohol, while potassium perchlorate does not dissolve. It is filtered, washed with methyl alcohol 4 or 5 times, and dried in a drier at 110°. The dried residue is weighed and reduced to potassium chloride. The factor for reducing $KClO_4$ to KCl is 0.538. M.V.C.

Barium oxide as enamel raw material. VIELHABER. *Emailwaren-Ind.*, **17** [33–34] 87–90; [35–36] 93–95 (1940).—Barium carbonate is the most important raw material for barium oxide in enamel. It can replace both alkaline earths and alkalis. It is a good flux and affects the heat expansion only slightly, while alkalis raise it considerably. This factor is especially important when economy is needed with boric acid (heretofore the only flux which did not lower the expansion to any extent). It may be used alone or in combination with zinc oxide, and it produces satisfactory enamel without boric acid. Barium carbonate (witherite), $BaCO_3$, crystallizes rhombically and occurs in vein ore. Its production as a white insoluble precipitate is described. In the enamel industry, barium carbonate is sometimes erroneously called barite (barium sulfate), and this confusion leads to grave errors. Barium and strontium salts, together with lime and magnesia compounds, belong to the group of alkaline-earth compounds. Barium salts are poisonous; strontium salts are less poisonous. Both are more easily fusible than the corresponding lime or magnesia compounds and impart a high brilliance to enamels. They also increase refractoriness. M.V.C.

Board of Experts. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 134–53.—A Board of Experts consisting of ten members answered sixty questions asked them by the audience during a 4-hr. session. F.J.Z.

Clay technology as applied to enamels. C. G. HARMAN. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 20–25.—A simple pattern of clay relationships is presented in graphic form. It is convenient to divide the characteristics and properties of clays into three groups. The primary group defines the composition. The secondary group may be considered to integrate the particle size distribution curves and to transform the chemical energies of particle surfaces into more flexible form. The derived group is composed of ion-adsorption phenomena or surface effects and of the packing characteristics of the particle. Base exchange is responsible for the sensitivity and responsiveness of clay to electrolytes. The three main groups of clay minerals, viz., montmorillonite, illite, and kaolinite, are described with reference to their action in enamels. The effect of salt additions on the properties of enamel slips may be estimated by considerations of hydrolysis and ionization of the compounds; thus, the general effect of any salt, acid, or base on the properties of enamel slips can be predicted if the chemistry of the involved salts is known. Base-exchange capacity, usually reported as the number of milliequivalents of cations characteristically associated with 100 gm. of clay, increases as the particle size of the clay decreases. Montmorillonite has the highest base-exchange capacity of the three groups of clay minerals, and kaolinite has the lowest. The suspending power of clays is approximately a linear function of the base-exchange capacity of the clay, providing the comparison is made with clays having the same species of ion adsorbed. F.J.Z.

Control of domestic enameling clays. FRANK ZVANUT. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 5–13.—Thorough studies of domestic clays by schools, enamel-frit manufacturers, and government agencies have shown that a number of domestic clays can supplant Vallendar clay successfully. With modern air-purification equipment, clay suppliers are selling powdered clays with a minimum of impurities and with definite uniformity in such properties as clay opacity and suspension. A reflectance-weight variable chart, which shows how clays vary in the amount of opacity they develop in a given enamel, is included. The suspension properties of a clay are known to vary considerably within the same bed of clay, and it is this constant variation in set characteristics that has proved most irritating to enamelers. To control this variation, it is possible to blend clays to produce any desired set within the limits of the clays used in the blending. Tests for set are described, and comparative data are presented for several clays. Z. recommends the following set test for control use: A 1500-gm. milling is made up as follows: 100 parts of powdered quartz, 7 (or 5) parts clay to be tested (5 parts of clay used for "high set" clay), and 66 parts of water. Milling time is 15 min. The slip is adjusted to a specific gravity of 1.60, and four 9 x 8 in. ground-coated sheets are dipped into the slip, hung vertically while draining, and dried. The dried slip adhering to the sheets, calculated in grams per square foot, is taken as the pickup value of the clay. This test for pickup has the following advantages over a similar test in which a regular ground-coat milling is used: (1) it

can be completed in 20 min.; (2) fineness of milling is constant; (3) soluble salts are reduced to a minimum; (4) normal temperature variations have no effect on results; and (5) operators are able to check their own and each other's results consistently. Z. points out that while the quartz-clay pickup test can be used successfully for controlling the set of a clay, the various methods for testing set in different clays can often produce misleading results. F.J.Z.

Cover-coat practice for quality ware. G. N. TUTTLE. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 112–19.—The ever-increasing popularity of vitreous enamel finishes for household appliances has created a demand for methods of testing and control which can be systematically applied to raw materials, to the process at appropriate points during production, and to the finished product. To maintain uniform results, all shipments of new raw materials, such as frit, clay, electrolytes, oxides, and opacifiers, must be checked against the standard. The age of milled enamel, temperature of enamel, water content, condition of mill linings and ball charges, fineness of enamels, and consistency should be carefully and periodically checked. T. discusses spray-weight control, drying, firing, and color matching. Good housekeeping, so essential to the production of quality ware, involves (1) systematic and orderly progress of work through the plant, (2) a place for everything and everything in its place, (3) full complement of accessories needed for each operation, (4) definite and regular cleaning schedule for all equipment, (5) scheduled cleanup of waste and equipment, and (6) provision of storage facilities, both temporary and reserve, for all equipment and materials. F.J.Z.

Development of American clays for enameling. EDWARD E. MARBAKER. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 13–20.—While no standard procedure has been set up for the evaluation of domestic clays and it is still necessary to make exhaustive practical plant studies, considerable information has been acquired concerning the nature and colloidal behavior of clays and the problems of slip control. 17 references. F.J.Z.

Development of two tentative standard tests. PAUL L. SMITH. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 130–33.—The impact test for measuring chipping resistance consists in striking repeated blows at increasing energy at the same spot until failure occurs. The standard specimen is a cylinder 9 in. long and 1 in. in diameter. The enamel is applied to a thickness of either 15 mils or 11 mils, depending on whether the enamel is to be a one-coat or a two-coat surface. The apparatus consists of a pendulum weighing about $^3/_4$ lb. swinging on a 9-in. arm, a base, a backstop, and V clamps which hold the specimen. The thickness of the enamel is measured with a Brenner gauge at six prescribed spots. The energy of the blow which causes failure is taken as the impact resistance of the particular spot, and the results on twelve prescribed spots are averaged. In the torsion test, a standard specimen is twisted until failure occurs. The specimen is an 8- x 2-in. strip of 20-gauge enameling iron, bent to form a 1-in. angle, 8 inches long. The enamel is carefully applied to a thickness of 13 to 17 mils, and load is applied to the clamped angle through a regulated flow of water. These two tests measure resistance to two major types of chipping. F.J.Z.

Effect of residual color on consumer acceptance of porcelain enamel whites. JOHN W. ILIFF. *Jour. Amer. Ceram. Soc.,* **24** [3] 97–100 (1941).

Enamel control, performance and cost. E. W. DIETTERLE. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 120–29.—D. presents a careful analysis of cost figures checked against two distinct enamel setups. Control tests and inspection can operate efficiently in promoting savings in all parts of the enamel shop. F.J.Z.

Enameling iron oxidation phenomena. L. C. ATHY AND P. C. STUPPT. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 89–99.—The oxidation behavior of several enameling irons during the initial stages of fire was investigated, and the effect of ground-coat refractoriness and of mill additions on the oxidation was studied. A rather wide variation in the oxidation rate of different enameling irons was noted. The mill formula and the type of ground coats used were found to influence oxidation behavior. A discussion is included. F.J.Z.

Evolution of the enameling iron sheet. J. M. VOLZER. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 65–73.—The production of sheet iron is traced through the blast-furnace conversion of iron ore and the refining methods in the open hearth. To meet the demand for high-grade finished metals, the steel manufacturer, in progressive steps, radically changed the three fundamental characteristics of the enameling sheet, viz., its chemistry, internal physical structure, and external or surface condition. F.J.Z.

Factors affecting reflectance. CLARK HUTCHISON AND F. W. NELSON. *Jour. Amer. Ceram. Soc.,* **24** [3] 92–96 (1941).

Fundamentals of enameling clays. L. A. LANGE. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 25–32.—Generally speaking, opaque clays have a high SiO_2/Al_2O_3 ratio compared with clear clays. There is some indication that clays with low ignition loss have less tendency to fish-scale. Clear clays generally have less dry strength than opaque clays, while opaque clays are finer in particle size than the clear clays. Two items of fundamental information, viz., base-exchange capacity and crystal lattice structure, should be of considerable interest and importance in explaining the properties of clay minerals. F.J.Z.

Infrared drying. E. J. PHELAN. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 45–52.—A gold-finished reflector is the most efficient reflector for infrared energy, being about 10% better than aluminum-finished reflectors. Infrared drying is not suitable for oil paints that dry by oxidation, but anything that dries by evaporation can be dried efficiently with infrared. Carbon and tungsten are employed as filaments in infrared lamps. Proper reflectors and proper installation of reflectors are necessary to attain maximum efficiency in infrared drying installations. P. describes a number of industrial installations using infrared drying. NORMAN H. STOLTE. *Ibid.,* pp. 52–60.—Experience indicates that the method of drying is not important as long as heat is applied in such a manner that evaporation takes place from the metal outward and surface drying is avoided. Infrared offers possibilities in the porcelain enamel field; although first experiments were not too encouraging, the development of larger bulbs and better reflectors has given more promising results. The reflector should be chosen on the basis of efficiency, maintenance, and cost. The base and sockets should be well ventilated to prevent failure of the basing cement. The reflectors should be so constructed that the focus can be easily adjusted. Moisture in vitreous enamelware is uniformly distributed in the coating and can therefore be evaporated by radiant heat. In a special test with infrared, all white coatings were dried successfully in less than 2 min. and ground coat in less than 1 min. F.J.Z.

Keeping the bugs out of porcelain enameling. J. E. HANSEN. *Enamelist,* **18** [3] 5–12 (1940).—Problems and difficulties in various enameling plants and their elimination are discussed under the following headings: blisters and copperheads, scumming, ground-coat contamination, black specks, "reboil" and "tails," and equipment troubles. In some cases gnats and other insects attracted by the light were actually responsible for black specks, such insects being found in the residue reclaimed from the spray booths. L.E.T.

Nepheline-syenite as mill addition in ground-coat enamels. FRED A. PETERSEN. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940,* pp. 109–12.—Among the advantages of the use of nepheline-syenite in ground coats are (1) a smoother enamel coat in some ground coats, (2) a tendency to decrease reboil, and (3) manipulation of maturing temperature possible with satisfactory

firing range. Possible disadvantages include the lighter color resulting and the semimat surface obtained. If properly used, however, nepheline-syenite will not affect adherence, thermal shock resistance, or workability. F.J.Z.

Porcelain Enamel Institute Ninth Annual Meeting. *Enamelist*, **17** [2] 23–26, 28, 30, 61 (1939); *Steel*, **105** [21] 30 (1939).—The following important questions were raised in regard to the use of porcelain enameled steel in the architectural field: (1) Does the material itself meet structural, weatherproofing, and fire-protection requirements consistent with safety in the uses to which it is put? (2) What limitations, if any, should be placed on the size of the units to be used? (3) What are the proper materials or constructions to which units should be attached? (4) What is the proper method of attachment? (5) How are the joints to be weatherproofed to keep out moisture? (6) What weatherproofing of supporting members is necessary? (7) What degree of fire protection will be provided by walls constructed as proposed? H.E.S.

Proper design of enamel driers and control of humidity within them. E. W. Dany. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 60–64; *Enamelist*, **18** [2] 5–8 (1940).—The primary purpose of drying is to remove the water from the wet enamel layer uniformly, without disrupting the particles in the surface or below the surface. With steam driers, the rate of evaporation is low, and there is minimum danger of surface hardening. These driers are cheaper to build and operate but require longer drying periods. Some enamelers prefer higher operating temperatures, less air changes per minute, and less time in the drier. F.J.Z. + L.E.T.

Reactions occurring during the firing of ground enamel and some of the resulting defects. Th. *Glashütte*, **70** [43] 561–63 (1940).—A discussion is given of the work of Meures and Dietzel (*Ceram. Abs.*, **13** [2] 31 (1934)) on the reactions taking place in the enamel and the surface of the underlying metal during firing and the causes of the appearance of copperheads and flyspecks. To determine whether a relationship exists between the composition of the enamel and the formation of these defects, experiments were made on a series of enamels in which boric acid was replaced by (1) sodium oxide and (2) sodium oxide and silicic acid (1:1). Fusion tests were made on enamels of varying composition to determine the relation between the chemical composition of the enamels and their property of dissolving iron oxide. The batch compositions are tabulated, and the conditions of the experiments are given. The series of tests showed plainly that with decreasing boric acid content in ground enamels, the dissolving capacity for iron oxide was reduced and vice versa. The oxidation capacity of the metal surface and the temperature and duration of firing are other factors conditioning the dissolving capacity of enamels for iron oxide. If sufficient dissolving agents are present in an enamel, it will be satisfactory. M.V.C.

Results of fine grinding of colors. Norman H. Stoltz. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 119–20; *Enamelist*, **18** [3] 12 (1940).—Black and red enamels improve in color and gloss with medium grinding, viz., 1 gm. on 200-mesh. Gray enamels also show marked improvement. In most cases where opaque frit is mixed with clear glass, the use of the opaque frit gives good coverage and one-coat work, and the fine grinding produces a uniform and smooth-appearing texture not possible with coarse grinding. F.J.Z. + L.E.T.

Stretch testing—a new method of measuring the attachment of porcelain enamel to sheet metal. J. E. Sams. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 73–89.—In the impact test for adherence, the areas studied are produced essentially by stretching, and on this basis it was considered feasible to elongate flat enameled specimens to provide a fractured enamel surface for gauging adherence. Areas 4 in. long and 2 in. wide were enameled in the ordinary manner and then subjected to tensional distortion in an Amsler tensile testing machine. The specimens were elongated to 8%. The rate of elongation seemed to have no effect. Large flat test areas are thus provided which can be accurately judged by sight, permitting comparisons to be easily and confidently made. The degree of attachment is based on the amount and fineness of the enamel particles clinging to the distorted metal surface. An interesting discussion is included. 10 references. F.J.Z.

Test for sagging of iron and steel sheets. F. R. Porter. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 69–73.—Sagging is the downward bending of the enameling iron during heating. P. reviews the tentative standard test for sagging. F.J.Z.

Treated water in the enamel industry. E. H. Shands. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 40–45.—Ordinary drinking water varies widely in impurities or suspended solids according to the locality in which it occurs. A typical water analyzing 20 gr. hardness per gal. will give, when computed in terms of the mill formula, $^1/_4$ ounce of solids per 100 lb. of frit. These solids are usually compounds of sodium, calcium, or magnesium, such as carbonates, bicarbonates, sulfates, and chlorides, which act as powerful electrolytes upon the milled enamel. Many of these materials impart only temporary set to the enamel and cause it to be erratic in set while being applied. Synthetic distilled water, i.e., water from which the solids have been removed chemically rather than by distillation, costs much less than regular distilled water and is effective in controlling the set in ground coats particularly. The preparation of synthetic distilled water depends upon a chemical reaction of the dissolved solids in the raw water and two organic materials. In this reaction the calcium and magnesium are exchanged for hydrogen ions, and the sulfates, chlorides, carbonates, and bicarbonates are exchanged for hydroxyl ions. As hydrogen ions are acidic and hydroxyl ions are alkaline, they immediately react to form water. Each reaction is complete except that involving the bicarbonate. The portion of this substance left unchanged can be removed by aeration as carbon dioxide. In this manner practically all of the soluble salts in the raw water are removed, and a pure water comparable to distilled water remains. The apparatus for producing synthetic distilled water and a regenerator are described. F.J.Z.

Use of nepheline-syenite in porcelain enameling. H. L. Cook. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 107–108.—Nepheline-syenite is readily absorbed by some ground-coat combinations, and C. describes results with ground coats using as high as 17% nepheline-syenite. The saving in cost amounts to about $^1/_4$ cent per lb. or approximately 60¢ per 1000 sq. ft. of ware. It is necessary to guard against loss of bond with increasing nepheline-syenite additions, but C. has used as high as 20% with no trouble. One distinct advantage of the nepheline-syenite addition is that a base ground coat is obtained which makes white coats slip and slide less in continuous furnace firing. The 17% addition of nepheline-syenite changes the color of the fired enamel only slightly but incurs no problems in draining, blistering, or reboiling. F.J.Z.

Use of sodium cyanide as a neutralizer prior to steel enameling. G. G. Grogan. *Proc. Porcelain Enamel Inst. Forum, Fifth Forum, Oct., 1940*, pp. 32–40.—A weak solution of sodium cyanide, about 0.2 oz. per gal., is just as efficient a neutralizer as a more concentrated solution. The weak solution has positive advantages: it is easily controlled, economical to operate, and safe to handle. Sheets neutralized in a cyanide solution are superior in appearance and cleanliness to those neutralized in a soda ash-borax solution because of the property of cyanide to form soluble iron salts with ferrous sulfate; soda ash precipitates insoluble iron salts which are carried over from the pickling tank and adhere to the surface after neutralizing. In the presence of acid, sodium cyanide neutralizer dissolves flash copper from the steel surface. Safety precautions and remedies in the case of accidental poisoning are enumerated. A lengthy discussion is included. F.J.Z.

Washing machines finished in modern plant. Bartlett West. *Products Finishing*, **4** [12] 46–48, 50 (1940). H.K.R.

Weathering of architectural enamels. Progress report. B. J. Sweo. *Enamelist*, 18 [3] 13–14 (1940).—No definite information is available on which the life of an enameled installation (signs) in outdoor service can be predicted. Exposure tests on 6- x 12-in. panels of 20-gauge steel were made at a vertical angle of 45° in Florida and Ohio. The effects noted as a result of 2½ years' exposure are as follows: (1) Color fading was negligible and occurred only on pastel shades. (2) No difference in weatherability was noted as a function of the firing temperature or as a function of the fineness of grinding of the enamel. (3) Almost all of the nonacid-resistant enamels showed slight scumming on exposure. (4) A few of the colored acid-resistant enamels also showed scumming. L.E.T.

White opacification in sheet and cast iron enamels free from borax. H. Lang. *Glashütte*, 70 [39] 509–11 (1940).—The difficulties of making satisfactory white enamel without borax can be overcome to a great extent if already fused materials which act as a flux are used as borax substitutes instead of simple raw materials such as soda, fluorspar, phosphate, etc. Chief among the prefused materials are powdered glass and commercial products in the form of glass frits, sometimes highly opacified, such as "milk glass meal." These materials melt down more smoothly and evenly, have a better temperature interval between the softening and fusing points, and improve the other properties of the enamel, especially the elasticity. If sodium fluosilicate is the main opacifier in such a batch, excellent white enamels can be made. In spite of the questionable merit of giving recipes, whose success sometimes depends more on working conditions, L. feels justified in giving the following new recipe for a white enamel which may serve as a parent formula and which has been proved by practical experience: feldspar 39.21, quartz 9.80, kaolin 4.90, milk glass meal 13.73, sodium fluosilicate 13.73, soda 13.73, and saltpeter 4.90; additions to the mill: 6 to 8% clay, 1% ammonium carbonate, 1% soda, and 1 to 3% opacifier. This recipe gives good opacification and has high covering power. It is fused at 820° to 850°; it is fairly resistant to acids, and two coats are sufficient for ordinary purposes. When 2% cerium oxide is fused with the enamel or added to the mill, a first class white enamel is obtained, one coat of which will suffice for certain objects. A good heavy ground enamel is required for this enamel. If hairlines appear, the ammonium carbonate content should be raised from 1% to 2 to 3%; if the enamel seems too hard, feldspar or quartz may be replaced by powdered glass and the clay addition to the mill kept at 6%. Further research is necessary if a more suitable preopacifier is to be found or if a post opacifier is to be perfected by practice. M.V.C.

SEPARATE PUBLICATION

Physical Properties of Sheet Steel Enamels Affecting Hairlining. E. E. Bryant. *Ferro Enamel Corp. Tech. Bull.*, No. 6, 23 pp. (Sept. 1, 1940).—All hairlines are caused by a break in the enamel coating during the cover-coat fire. These breaks are produced by areas of strain which cause tensile failure in the enamel coating. Good shop practice in the form of proper design of shapes, proper firing, and maintenance of thin coatings of enamel in many cases will eliminate breaking of the enamel coating. Any possible variation of the physical properties of individual enamels has only a slight effect on the resistance to breaking. After a break occurs, surface tension and mobility of each coating during cover-coat firing and wetting or adherence between coatings during cover-coat firing materially affect hairlining. Cross sections of the brushed edge of cover coats show definite variations which are accounted for in terms of surface tension and mobility of the individual coatings and adherence between the coatings during cover-coat firing. These factors determine the relative ability to seal over a break during cover-coat firing which is relative hairline resistance. F.J.Z.

PATENTS

Coating the interior of tanks with vitreous enamel. H. E. Schabacker (Erie Enameling Co.). U. S. 2,229,526, Jan. 21, 1941 (Nov. 30, 1938).

Glazes and enamels. British Thomson-Houston Co., Ltd. Brit. 531,146, Jan. 8, 1941 (July 15, 1938).

Making enamelware. J. E. Rosenberg (Enamelers Guild, Inc.). U. S. 2,229,524, Jan. 21, 1941 (Jan. 14, 1939).—The method of developing upon the surface of a steel article two superposed coats of enamel of unstained superficial appearance consists in firing upon the steel surface at full enamel-maturing temperature and for substantially 2½ to 3 min. a coat of melted frit that in molten state carries an antimony pentoxide ingredient, cooling, and firing upon the so-developed ground coat at full enamel-maturing temperature and for substantially 2½ min. a second coat of melted frit.

Producing ceramic glazes, glasses, and enamels. Dietrich Harkort. Ger. 679,866, July 20, 1939 (Feb. 5, 1934); VI/80*b*. 23.03.—Ceramic glazes, glasses, and enamels are produced from the intermediate and end products of lead-ore dressing and smelting which contain sulfates, such as the usual industrial by-products containing sulfates. The starting material, after the sulfides have been oxidized by a preliminary firing, is treated by adding an oxidizing material which is reactive at temperatures above 650°C., such as metal carbides, e.g., silicon carbide, or pulverized metals, e.g., aluminum dust. The material is then worked up to lead frit with heat, and the other constituents of the glazing batch are added before or during the transformation of the sulfates. D.A.B.

Glass

Alkali-free glasses. O. Knapp. *Glass Ind.*, 21 [3] 115–16 (1940).—According to accepted definitions of glass, alkali oxides are essential components. Technical glasses, however, may require freedom from alkalis. Data on composition, inventors, uses, and properties are listed for 31 silicate, 7 borate, 7 phosphate, and 3 plumbate glasses. A.P.

Bottles for internal pressure. F. W. Preston. *Glass Ind.*, 21 [6] 272–73, 283 (1940).—Esthetic considerations, the search for distinctiveness, and ease of handling may lead to designs of bottles that are unsuitable for holding internal pressure. Any large departure from a circular shape calls for a great deal more glass or a great reduction of internal pressure. Design is only one of the factors; distribution of the glass, evenness of annealing, and integrity of the outer surface are also important. A.P.

Briquetting of glass mixes. V. Čtyroký. *Sklářské Rozhledy*, 17, 3–10 (1940); abstracted in *Chem. Zentr.*, 1940, II, 114.—Briquetting of the mix had no evident effect on the rate of fusion but hastened the penetration of heat through the mix. The homogeneity of the glass melt before refining is increased by briquetting. This effect is most marked in the case of Na-K-Ca silicate glass, and less noticeable in Pb glass; in borosilicate glass, only local homogeneity is increased. The loss of alkali and H_3BO_3 is reduced by briquetting. The number of bubbles is greater on the floor of the crucible and less on the surface of the briquetted glass melt. M.V.C.

Buck Glass Co. modernizes batch handling. Anon. *Glass Ind.*, 21 [3] 101–103 (1940).—Handling mixed batch in unit containers from the mixer to the doghouse, standardized tramrail equipment solves a single-tank plant's problems of segregation, storage, dust, and labor requirements. 6 photographs. See "Warehouse . . . ," *Ceram. Abs.*, 20 [3] 66 (1941). A.P.

Building the 200-inch telescope. C. S. McDowell. *Jour. Franklin Inst.*, 224, 675–95 (1937).—Tests show that a telescope larger than 200 in. would not be desirable. The mirror is made *f* 3.3 as the limit of good correction. A faster mirror does not show fainter stars because of sky

fog; this appears in 36 min. at *f* 3.3. The telescope may be divided into five components: (1) optical system, (2) mirror support, (3) telescope tube and mountings, (4) precision drive, and (5) dome. The mirror is made of super-Pyrex brand glass with 36 pockets in the back for support. No point in the mirror is over 2 in. from an outside surface. The support mechanism is so adjustable that it will bear its proportion of the weight in any position and thus prevent local strain. The telescope tube will not deflect over $^1/_{16}$ in. and will prevent angular displacement of the optical system. The drive mechanism will permit a smooth movement of 0.1 sec. of arc. A crystal-controlled sidereal clock will do the driving. The dome will be 135 ft. in diameter and almost that high. See "Glass. . . ," *Ceram. Abs.*, **19** [1] 35 (1940). W.D.F.

Chemical durability of glass. A. K. LYLE AND D. E. SHARP. Presented at meeting of Glass Division, American Ceramic Society, Hershey, Pa., Sept., 1940; abstracted in *Glass Ind.*, **21** [10] 453 (1940). A.P.

Chemical methods for increasing the transparency of glass surfaces. F. L. JONES AND H. J. HOMER. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 654 (1940). A.P.

Chemical stability of glass in dependence on its thermal history. O. S. MOLCHANOV. *Optiko Mekh. Prom.*, **10** [6–7] 7–8 (1940).—The temperatures (*Tg*) of annealing and viscosity lie within the range of the change in chemical stability. Curves of the chemical stability of different glasses (flint and crown) are discussed. M.V.C.

Crystallization relationships of a soda-lime-magnesia-silica glass as used for drawn sheet and the process of devitrification. ERIC PRESTON. *Jour. Soc. Glass Tech.*, **24** [104] 139–58 (1940).—The gradient method was employed for the determination of the crystallization-temperature-time relationships of a sheet glass of the following percentage composition: 72.15 SiO_2, 2.02 R_2O_3, 8.91 CaO, 2.05 MgO, 13.58 Na_2O, 0.73 K_2O, and 0.04 SO_3. The liquidus temperature was 965°, and the binary eutectic temperature was 850°. The formation of the ternary eutectic was not observed. The temperature of maximum crystal growth was 910°. Examples are given showing the rate of crystal growth at different temperatures, the effect of time on crystallization, and the separation of the binary eutectic of devitrite and silica. The shape of the crystallization-temperature curve is considered in relation to the equilibrium diagram and the viscosity of the glass. In a first approximation, above the temperature of maximum crystal growth, crystallization is proportional to the temperature interval below the liquidus temperature; below the temperature of maximum crystal growth, crystallization is inversely proportional to the viscosity. The early stages of crystallization can be represented by an equation of the following type:

$$r = Ce^{-A/T_{Abs.}}(T_{Liq.} - T),$$

in which *r* is the rate of crystal growth and *A* is a constant deduced from the viscosity-temperature relationship of the glass. The process of devitrification is discussed from the viewpoint of the equilibrium diagram of the soda–lime–silica system with the aid of a perspective drawing of a portion of the equilibrium model relevant to commercial glass compositions. Correlation of the results obtained on commercial soda–lime–silica glasses with the known equilibria conditions for pure glasses would ultimately lead to a representation of the effects of minor constituents on the crystallization properties of such glasses. G.R.S.

Departmental researches in glass. C. W. PARMELEE. Read at Sixth Conference on Glass Problems, University of Illinois, May, 1940; abstracted in *Glass Ind.*, **21** [6] 275 (1940). A.P.

Determination of the devitrification temperatures of glasses. ERIC PRESTON. *Jour. Soc. Glass Tech.*, **24** [103] 101–108 (1940).—A modified gradient method of devitrification-temperature determination is described, and results from it are compared with those previously obtained by workers employing the classical quenching method. The method is shown to be reliable and capable of giving information at the same time on the rate of crystal growth at temperatures throughout the devitrification range. Examples of errors due to nonestablishment of equilibrium and surface devitrification brought about by volatilization of one or more of the glass constituents are described. G.R.S.

Determination of the properties of glass by the additivity rule. PAUL BARY AND JEAN HERBERT. *Ind. Chim. Belge*, **10**, 481–87 (1939); *Chem. Abs.*, **34**, 5258 (1940).—Previous results of a method of calculating the density of glasses are expanded; hypotheses on the combinations of the various elements of glasses support the theory that normal glasses are formed of chains of SiO_2 connected by molecules of silicates of bivalent metals, alkaline silicates forming the part in solution in the system of long molecules. The theory does not apply to special glasses less rich in SiO_2 whose systems do not consist of simple polysilicic chains. Zachariasen's views based on the X-ray study of the atomic arrangement in glasses are confirmed by this theory. See *Ceram. Abs.*, **18** [2] 46 (1939).

Dispersion of silicate glasses as a function of composition. M. L. HUGGINS. *Jour. Optical Soc. Amer.*, **30**, 514–18 (1940).—With one constant per element (other than oxygen) in addition to the one needed for the calculation of refractive indices for a single wave length, the dispersion in the visible range can also be computed. In systems for which the most accurate data are available, the average deviation between experimental and calculated values for $n_F - n_C$ is about 5 to 8 × 10^{-4}. See "Density. . . ," *Ceram. Abs.*, **20** [2] 41 (1941); "Refractive. . . ," *ibid.*, p. 42; "Symposium. . . ," *ibid.*, p. 42. A.P.

Effect of composition and other factors on the specific refraction and dispersion of glasses. JOHN C. YOUNG AND ALFRED N. FINN. *Jour. Research Nat. Bur. Standards*, **25** [6] 759–82 (1940); RP 1352. Price 5¢.—Seven of the better known specific-refraction ratios were examined for their comparative applicability to glass. It is shown by a comprehensive statistical treatment of available data (including many new data) that, of these ratios, only the Gladstone-Dale possesses each of the following desirable features to a satisfactory degree: (1) it varies linearly with chemical composition and with the square of the wave number of the incident light; (2) for a given composition and wave length of light, it is substantially the same for both the vitreous and crystalline states; and (3) for the vitreous state, it is independent of thermal history. Gladstone-Dale factors for 47 oxides as constituents of glass (and corresponding factors derived from nonglassy substances) are given. These factors are related to the periodicity of the elements. Specific dispersion factors useful for computing the dispersion index, or *p*-value, of a glass are given for 32 oxides. R.A.H.

Effect of sulfur gases on surfaces (a review). ANON. *Glass Ind.*, **21** [1] 24–25 (1940).—While the benefits of bloom, natural or artificially produced, are well known and the chemistry of the reaction is fairly well understood, further study of the subject might result in an improved technique. 21 references. A.P.

Effect of variable concentration of alkali in the silvering solution on the process of reducing silver. V. M. VINOKUROV. *Optiko Mekh. Prom.*, **10** [5] 13–16 (1940).—Experiments showed that (1) the thickness of the silver deposit increases with the alkali content in the silvering solution; and (2) the initial velocity of deposition of the silver does not depend on the alkali concentration but slows down in an irregular way during the process. M.V.C.

Elastic and viscous properties of several potash-silica glasses in the annealing range of temperature. N. W. TAYLOR AND R. F. DORAN. *Jour. Amer. Ceram. Soc.*, **24** [3] 103–109 (1941).

Flaking of glass containers. W. R. LESTER. Presented at meeting of Glass Division, American Ceramic Society, Hershey, Pa., Sept., 1940; abstracted in *Glass Ind.*, **21** [10] 434 (1940). A.P.

Flow measurements in the glass industry. A. J. MONACK AND E. E. BEETON. *Glass Ind.*, **21** [9] 392–94 (1940).—Flow measurements are an accurate method for duplicating and controlling fires using liquid or gaseous fuels. Apparatus in general use for measuring flow are thin-plate orifice meters, Venturi gauges, and flow nozzles. Designs for Venturi tubes are given which simplify the use of flow gauges in small gas lines. A.P.

From theory to practice at Hartford-Empire. ANON. *Glass Ind.*, **21** [5] 231–35 (1940).—By means of recently enlarged facilities the Hartford-Empire Co. has expanded its studies in the technology and manufacture of glass, ranging from fundamental research to actual manufacturing. 19 photographs. A.P.

Fundamental studies of the glassmelting process—effect of particle size and temperature on the rate of glass formation of a pure soda-lime-silica glass. ERIC PRESTON AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **24** [103] 124–38 (1940).—A study was made of the rate of melting, in small platinum elliptical capsules heated in an electric furnace, of a batch mixture (approximately 2.5 gm.) yielding a glass of the percentage composition 73.5 SiO_2, 10 CaO, and 16.5 Na_2O. Pure soda ash and calcium carbonate, both of controlled, constant particle size, were employed together with silica grains in one of two forms, the first derived from pure Brazilian quartz and the second from a sieved Dutch sand. Quenched Brazilian quartz was found to break down with peculiar characteristics leading to grains mainly of columnar or needle shape. A series of experiments at temperatures ranging from 1100° to 1450° showed that the rate of glassmelting was approximately doubled for each 50° rise in temperature. The rate at any one temperature was found to be proportional to the area of the grains of silica. The violent chemical reactions were found to occupy 10% of the total time of glassmelting, and the solution of the residual silica occurred at the rate of 0.003 mm. per min. reduction in average grain diameter. G.R.S.

Glasslike state of substances. A. A. APPEN. *Uspekhi Khim.*, **8**, 1461–1518 (1939); *Chem. Abs.*, **35**, 287 (1941).—A. reviews the literature, chiefly non-Russian. He considers the chemical composition of glasses, the physical characteristics of the glasslike state and change of physical properties with time and temperature, and the molecular state of glasses and then discusses critically the Tammann, colloidal, crystallite, and disordered-lattice hypotheses of glass structure.

Glass makes highways safer. ANON. *Glass Ind.*, **21** [7] 323 (1940).—A new device, the Traffiscope, has been set up in different parts of the country to test its utility for extending vision over the crest of hills. A.P.

Glass manufacture in Germany. H. SCHULZ. *Glashütte*, **70** [42] 549–51 (1940).—The history of glassmaking is intimately connected with the cultural growth of man, and almost every people had a part in the development of the art of melting and working glass except nomadic tribes whose unsettled state precluded any work requiring stationary equipment, specified raw materials, and long preparation. Egypt, Mesopotamia, and Rome attained a high degree of knowledge and skill in glassmaking, which was then spread over the Roman provinces by merchants and migrating workers. It is suggested that the use of different shades and colors of glass panes for making decorative figures in stained glass windows possibly originated in the Germanic provinces as early as the 10th century. The evolution of the production of glass through the centuries proceeded in the following steps: In the 16th and 17th centuries Georg Agricola, Antonius Neri, Merret, and Kunckel, among others, laid the foundation for the development of the chemical technology of glass; discoveries followed, many by accident, e.g., the use of cobalt for blue coloring by Christopher Schürer in the first half of the 16th century. Important contributions to the chemistry and technique of glassmaking were made by Klaproth (1743–1817), Frauenhofer, and Guinand. F. Siemens made innovations in glass-furnace construction in the 19th century which opened up a new era for the glass industry. The more accurate measurement of temperature was achieved later. Physicists and chemists then sought to establish glasses in a chemical system of minerals according to standard formulas. New ingredients, such as boric acid, barium oxide, zinc oxide, and alumina, were introduced into glasses by Schott, and new groups of glasses were developed with an improved technique in fusing, refining, and cooling. The scientific knowledge of glass production has been enormously extended by research. M.V.C.

Glass melts in the systems zirconia–alumina–silica and titania–alumina–silica. A. E. BADGER AND L. M. DONEY. *Glass Ind.*, **21** [7] 309 (1940).—Thirty mixtures each in the zirconia–alumina–silica and titania–alumina–silica systems above 50% SiO_2 were melted in zircon crucibles at 1680°C. Fragments from these melts were also heated in an oxy-hydrogen flame (above 2000°C.). Plots on triaxial diagrams indicate the composition ranges and the areas of homogeneous glass, of vitrified material, and of material in which vitrification had proceeded only to the sintering stage. An apparatus was designed to measure the thermal expansion of glass fibers. Zirconia-containing glasses had refractive indices ranging up to 1.625, while titania glasses reached values up to 1.650. Thermal-expansion coefficients were found to lie in the range 13 to 23 $\times 10^{-7}$ for zirconia glasses and somewhat higher for titania glasses. A.P.

Glassmen honored as modern pioneers. ANON. *Glass Ind.*, **21** [3] 104–105 (1940).—Seven glassmen were among those honored at ceremonies in observance of the 150th anniversary of the U. S. Patent system. Their outstanding accomplishments are summarized. A.P.

Glass stones. C. L. THOMPSON. Presented at meeting of Glass Division, American Ceramic Society, Skytop, Pa., Sept., 1939; abstracted in *Glass Ind.*, **20** [10] 362 (1939). A.P.

Handmade glassware and reciprocal treaties. ANON. *Glass Ind.*, **21** [2] 51–56 (1940).—Since 1935, the American handmade glassware industry has had five tariff readjustments. The practical effects of the Hull reciprocal trade treaties on this industry are given in statistics and descriptions of the cooperative factories of Maryland and West Virginia. 20 photographs. A.P.

Heat-flow calculations. ANON. *Glass Ind.*, **21** [5] 236–38, 250 (1940).—The mechanics and the mathematical expression of heat flow through glass-furnace walls are considered, and the calculations are applied to several practical problems. A.P.

Injury from broken glass. K. H. BORCHARD. *Glashütte*, **70** [41] 533–35 (1940).—The importance of constant supervision of the quality of glass products and thorough testing of all pieces for the rejection of defectives to safeguard workers and the public is shown by a discussion of the spontaneous explosion of a mineral-water bottle. A human eye was lost, and suit was brought against the bottle manufacturer. In attempting to establish the validity of the claim, a careful study was made of the character of the fracture, cooling tensions, inside pressure, time factor, temperature (the accident occurred on a hot day), effect of the size of the air space above the mineral water, etc. From his extensive research on bottle fractures, B. has found that the zone of greatest strain in a glass bottle is that point where the cylinder meets the "breast"; the walls are thinnest and the diameter is greatest. The nature of a cross section of a normal break as studied by B. is described. Around the point of the flaw from which the break proceeds is a shiny surface which may be wavy near the flaw; around this zone and in the same plane is a mat surface; next is the third zone, below and above the mat zone, which is deeply grooved in the direction of the break. The break then forks out around the neck and the base. Statistics based on many tests show that the size of the shiny surface is related to the duration of the pressure on the bottle wall previous to the break. The legal evidence obtained in this case of breakage was not sufficient to justify a claim against the bottle manufacturer. M.V.C.

Investigation of the chemical stability of glasses by the Tepohl method. L. P. BANIN. *Optiko Mekh. Prom.*, **10**

[6–7] 13–15; [8] 17–20 (1940).—When determining the chemical stability of glass by the Tepohl method (*Ceram. Abs.*, **17** [6] 214 (1938)), an additional operation of washing the glass with rectified alcohol to remove glass dust is necessary. It is impossible to compare the results of the Tepohl and Peddle methods because they are expressed in different units. Some glass shows a different chemical stability when treated with water and acid; hence, it is necessary to test glass with both water and acid. These experiments should be made under similar conditions of temperature, time, grain size, and surface, and the results should be expressed in the same units. M.V.C.

Iron arm for taking up fused glass. F. JOCHMANN. *Glashütte*, **70** [39] 511–12 (1940).—Iron arms for taking up fused glass consist of an iron shaft or handle with a heavy spherical head of iron or clay on one end. Iron impurities which come off the head while in use are the cause of devitrification and white streaks in finished glass. The substitution of clay heads for iron heads also had drawbacks. A new lighter-weight arm was devised by Martin Kretschmer (Ger. Pat. 687,563, Jan. 11, 1940), the head of which is made of high-quality heat-resistant steel. The head and part of the handle are hollow, and this hollow space is connected with the outside air by an opening in the handle. The head may be welded to any arm. Illustrated. M.V.C.

Kyanite as a glass stone. W. R. LESTER. *Glass Ind.*, **21** [9] 395–96 (1940).—Occasionally, stones have been identified as unaltered or partially altered kyanite grains. Those occurring during a recent siege of stoney glass were traced to 0.25% of kyanite in a sand used for colored glass. Although the grains should have dissolved in the melt long before reaching the feeder, conditions of furnace pull, temperature, and glass-flow currents permitted them to appear in the finished glass. A.P.

Lamb Glass Co. adopts luminous-flame firing. ANON. *Glass Ind.*, **21** [6] 267–71 (1940).—One of the melting tanks in the Mt. Vernon, Ohio, plant of the Lamb Glass Co., milk-bottle manufacturers, has been rebuilt with new features of design. Natural gas is used with a controlled method of luminous-flame firing. 10 photographs. A.P.

Light-sensitive glass and its application for ultraviolet measurements. L. O. UPTON. *Glass Ind.*, **21** [3] 109–12 (1940).—Soda-lime glass to which has been added 0.5% of cerium oxide and 0.5% of vanadium is used in the form of rods 50 mm. long and 1 mm. in diameter with fire-polished ends. When exposed to sunlight or artificial ultraviolet light between 3000 and 3800 a.u., the glass changes from green through yellow, orange-yellow, pink, and light purple to a final dark purple. By suitable calibration, the rods can be used to measure the quantity of ultraviolet light over extended periods of time. Phosphoric acid or boric acid additions inhibited the photochemical reaction. Climatological, biological, and material-testing applications are cited. A.P.

Marble manufacture at Peltier Glass Co. ANON. *Glass Ind.*, **21** [2] 64–66 (1940).—One-half to one billion marbles a year are produced by seven American factories. Operating practices at Sellers H. Peltier's factory at Ottawa, Ill., are sketched. A.P.

Metal molds for glass products. A. H. DIERKER. *Ohio State Univ. Eng. Expt. Sta. News*, **12** [5] 8–14 (1940).—An ideal material for a mold would be (1) close grained and highly polishable, (2) resistant to heat shock and fire cracking, (3) free from warping, (4) high in thermal conductivity, (5) easily machined, and (6) of moderate cost. No one material has all of these properties. Materials used are plain cast iron, alloyed cast iron, plain carbon steel, high alloy steel, plated iron or steel, and nonferrous alloys. Most of the molds are plain cast iron, cast to give the working face a chill. The three chief troubles are (1) cracking, (2) sticking, and (3) dirty ware. Molds are subjected to repeated thermal shocks, the working face often exceeding 1000°F. The temperature at any one point varies through one cycle for the production of one piece of ware. The temperature may be increasing at one point and decreasing at a neighboring point. A high-carbon cast iron decreases cracking, but the graphite flakes prevent a high polish. It might be advisable to stress-relieve new molds just after casting. Sticking must be avoided at all costs. A sooty material helps to prevent it. Enamels are made to stick by an oxide layer. As poor wetting is wanted, experiments run to obtain it showed least wetting on phosphate-treated iron (rust-proofed). Dirty ware is caused by an accumulation of foreign material or by deterioration of the metal due to high temperatures or reaction with gases, lubricant, or glass. W.D.F.

Monopoly suit. F. W. PRESTON. *Glass Ind.*, **21** [2] 69–72 (1940).—The suit of the U. S. Government against the glass-container industry is discussed. A.P.

New kinds of colored glasses. G. N. ROUTIAN. *Optiko Mekh. Prom.*, **10** [8] 9–14 (1940).—New kinds of colored glasses with their curves of absorption and optical densities are described. M.V.C.

Oil firing technique as perfected by Anchor-Hocking. ANON. *Glass Ind.*, **21** [7] 313–15 (1940).—At Salem, N. J., the Anchor-Hocking Glass Corp. utilizes oil fuel for all heating purposes except annealing and has perfected a combination of method and equipment that produces excellent results. A.P.

Opal glass. N. J. KREIDL AND W. A. WEYL. *Glass Ind.*, **21** [2] 57–62, 82 (1940).—An extensive survey of opal glasses includes (1) a brief literature review, (2) optical properties, (3) types of opacification (crystallization, insolubility, immiscibility, gas, and mixed), (4) fluorine opal glasses, (5) influence of chemical composition on fluorine opals, and (6) chloride opal glasses. A.P.

Paper strips on windows. G. CUNNINGHAM AND TRIPLEX SAFETY GLASS CO., LTD. *Pottery Gaz.*, **65**, 72 (1940); *Jour. Soc. Glass Tech.*, **24** [101] 59A (1940).—Data are given on strength tests carried out on samples of glass 12 in. square subjected to the impact of a steel ball weighing $^1/_2$ lb. The height of fall was increased until the sample broke into two or more pieces. Cracking of the glass alone was not recorded as a break. The reinforcing material was in the side remote from the impact of the ball.

Physicochemical investigation of the molecular structure of glasses. E. KORDES. *Z. Anorg. & Allgem. Chem.*, **241** [1] 1–38 (1939). **Discussion.** W. BILTZ AND F. WEIBKE. *Ibid.*, pp. 39–41. **Reply.** E. KORDES. *Ibid.*, [4] 418–20. **Further discussion.** W. BILTZ AND F. WEIBKE. *Ibid.*, pp. 421–22. See *Ceram. Abs.*, **18** [9] 239–40 (1939); "Relation . . . ," *ibid.*, [11] 294; *ibid.*, **19** [1] 10 (1940). W.K.

Portland cement in glass-batch briquettes. R. L. SHUTE AND A. E. BADGER. *Glass Ind.*, **21** [1] 28 (1940).—Portland cement as a binder for glass batches has the merits of being low in cost and of furnishing alumina, but it is high in iron. See "Binding . . . ," *Ceram. Abs.*, **19** [8] 185 (1940). A.P.

Quantitative spectral analysis of boric oxide in glass: I. KENZO HARAI. *Jour. Chem. Soc. Japan*, **60**, 668–74 (1939); *Chem. Abs.*, **34**, 231 (1940).—The powdered sample of glass is placed in a Cu electrode. A direct arc is made, and the arc is studied spectrographically. Log ($[B_2O_3]/[SiO_2]$) and log ($I_{B_2O_3}/I_{SiO_2}$) lie roughly in a straight line, where $[B_2O_3]$ is the quantity of B_2O_3 in the glass and $I_{B_2O_3}$ is the intensity of spectral line.

Recent trends in glass composition. D. E. SHARP. *Glass Ind.*, **21** [4] 158–62 (1940).—Changes made during the last two decades may be described as minor changes in major ingredients or major changes in minor ingredients, especially the latter. 47 references. A.P.

Reducing block erosion at the glass level. R. L. SHUTE. *Glass Ind.*, **21** [3] 106–108 (1940).—Air blasts, water, and steam jets are compared as cooling means. The use of thinner blocks in the wall construction, either in the top course only or in the entire wall, permits more effective air cooling. As the walls wear thinner, they are backed up with auxiliary blocks. Another method uses a water cooler between the top of the wall and the underside of the breast wall. This prevents the fluxes floating on the surface of the melt from coming in contact with the re-

fractories and also screens the top of the blocks from direct flame. A.P.

Relations between storage and accelerated chemical durability tests for several glass compositions. A. K. LYLE. Presented at meeting of Glass Division, American Ceramic Society, Skytop, Pa., Sept., 1939; abstracted in *Glass Ind.*, **20** [10] 363 (1939). A.P.

Simplex channel tank. ANON. *Glass Ind.*, **21** [9] 400–401 (1940).—A patented method for making clear homogeneous glass in continuous tank furnaces is said to be particularly suitable where quality requirements are high and production is small. A.P.

Sources of error in high-frequency measurements of the dielectric properties of glass. ROSEMARY HUDSON. Presented at meeting of American Physical Society, South Hadley, Mass., Oct., 1938; abstracted in *Phys. Rev.*, **54** [9] 866–67 (1938).—Sources of error in measurements of power factor at high frequencies were studied by the resistance variation method to determine whether the rise in power factor of certain glasses at frequencies above 10^8 or 10^9 found by various observers is a spurious effect. Since the power factor is represented by $R\omega C$, where R is the equivalent series resistance of the condenser, possible sources of error which might cause an apparent rise in power factor at high frequencies included the resistances of the leads and electrodes of the condensers and the stray reactances of the leads. If stray reactances exist in the leads to a condenser, the effect on apparent capacity of stray capacity is a constant for all frequencies, but the effect of stray inductance is to increase the effective capacity as the frequency increases. Small differences in length or position of the leads to the precision and test condensers produced a difference in inductance which was not negligible at high frequencies, and when these differences were carefully eliminated the observed capacity was constant over the range of high frequencies used. Under these conditions the measured power factor still increased with frequency at frequencies above 10^8. Experiments are now in progress to determine whether this rise can be accounted for by inequalities in resistances. J.L.G.

Spray gun used for new silvering process. ANON. *Ceram. Age*, **35** [3] 74 (1940).—The use of a compressed-air spray gun for silvering mirrors is briefly described. Illustrated. See "Improved . . . ," *Ceram. Abs.*, **19** [5] 111 (1940); "Revolutionary . . . ," *ibid.*, p. 112. F.G.H.

Staining glasses with silver: a possibility of studying inhomogeneities. J. C. TURNBULL AND W. A. WEYL. *Glass Ind.*, **21** [1] 13–18, 34–35 (1940).—Based on the migration of silver ions into finished glass from the outside, the silver staining method promises to help in classifying and tracing to their sources certain cords and striae. Glass in glass inhomogeneities can be detected by the difference between the cord and the surrounding normal glass in a certain property, e.g., viscosity, refractivity, thermal expansion, or color. Silver staining is very specific in indicating zones of different degrees of oxidation which do not have color differences in the visible range. Nine photographs illustrate results obtained with flint-glass bottles. A.P.

State of aggregation in glass. R. E. LIESEGANG. Translated in *Glass Ind.*, **21** [1] 19–20 (1940); see *Ceram. Abs.*, **19** [2] 43 (1940). A.P.

Tensions in glass apparatus. H. A. KAMPHAUSEN. *Glas & App.*, **20**, 103–104 (1939); *Chem. Abs.*, **33**, 7505 (1939).—K. distinguishes between and discusses three principal kinds of tensions occurring in glass apparatus characterized as tensions proceeding from the melting together of glass parts, from the cooling of the glass, and from the differences in the expansion of parts melted together consisting of different kinds of glass.

Thermal stability of glass. E. V. PODUSHKO. *Optiko Mekh. Prom.*, **10** [4] 13–16 (1940).—On the basis of data from literature, a brief analysis is given of the factors affecting the thermal stability of glass, such as (1) composition of glass, its thermal properties (coefficient of thermal expansion, conductivity, and capacity), and its mechanical properties; (2) shape and thickness of the glass; (3) state of annealing; (4) state of the glass surface; (5) inhomogeneities present in the glass; and (6) conditions of heating and cooling. M.V.C.

Throatless tank with suspended back wall improves Fiberglas melting. ANON. *Glass Ind.*, **21** [9] 387–91 (1940).—The design of a new melting furnace at the Newark, Ohio, plant of the Owens-Corning Fiberglas Corp. was required by previous difficulties with devitrification and corrosion of the checkers. 13 photographs. A.P.

Twenty years of progress in glassforming machines: I, Machines for containers and other glassware. ANON. *Glass Ind.*, **21** [4] 171–76 (1940).—Four groups of machines are considered: (1) press, (2) press-and-blow, (3) narrow-neck, and (4) paste-mold. **II, Machines for flat glass and tubing.** F. W. ADAMS. *Ibid.*, pp. 177–79.—Processes for plate and window glass, tubing, and rods are described. A.P.

Twenty years of progress in glassmelting. F. G. SCHWALBE. *Glass Ind.*, **21** [4] 169–70, 202 (1940).—Superficially similar, the modern furnace is immensely improved over its prototype. Checker depths have increased to 18 ft. from the depth of 8 ft. used in 1920 practice. Melting rates have tripled. Instrument control has progressed almost to the fully automatic stage. The study of convection currents in the furnace and the perfection of batch preparation and charging methods should have definite effects on future design and practice. A.P.

Twenty years of progress in glass plant materials handling. F. E. BARDROF. *Glass Ind.*, **21** [4] 163–68 (1940).—With larger and more continuous melting units, manual handling methods have been largely replaced by power-driven equipment for handling coal and cullet; weighing, collecting, mixing, and transporting batch; furnace charging; and dust collecting. 17 photographs. A.P.

WPA producing decorative glass. ANON. *Glass Ind.*, **21** [9] 398–99 (1940).—Fine pieces of decorative glassware are being produced by a WPA unit which is reclaiming skilled glassworkers from pick-and-shovel jobs and using an idle factory at Vineland, N. J. Six photographs illustrate the utilitarian and decorative products. Stained glass will also be made. A.P.

X-ray study of potash-silica glass. J. BISCOE, M. A. A. DRUESNE, AND B. E. WARREN. *Jour. Amer. Ceram. Soc.*, **24** [3] 100–102 (1941).

PATENTS

Apparatus for drawing an endless glass band. GEORG KILIAN AND ROBERT STROHSCHNEIDER (Deutsche Tafelglas A.-G. [Detag]). Ger. 685,687, Nov. 30, 1939 (June 13, 1938); VI/32*a*. 23.01.—An endless glass band is drawn by employing dies or tools for forming the band. They are arranged in the glass furnace in which the glass melt is heated by means of electrodes (electric resistance heating) placed in the drawing hearth under the glass surface. These special bar electrodes are inserted into the melt through the side walls of the hearth in the plane of the glass band which is being drawn from the furnace so that the end of at least one of the electrodes producing the heat with alternating current is placed almost vertically under the end of the aperture of the die or tool employed to form the glass band. D.A.B.

Apparatus for feeding liquids containing abrasive material onto glass surfaces being ground. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Ger. 685,883, Dec. 7, 1939 (March 26, 1934); XII/67*a*. 27.—The apparatus feeds liquids containing abrasive material onto glass surfaces which are being ground. This liquid is fed at several points at regular intervals and in definite amounts as an intermittent stream going through the main line and then through a branch line. A measuring vessel is arranged in a known manner with the branch line, through which, except during the feeding period, the liquid from the main line flows. The time of the feeding period is determined by regulating a closing valve connecting the vessel with the branch and the opening of the valve connecting with the spraying point. D.A.B.

Apparatus for grinding nonspherical concave and convex surfaces on lenses. WASILIY I. ANTONOFF. Ger. 680,591, Aug. 10, 1939 (July 8, 1929); XII/67*a*. 19. D.A.B.

Apparatus and method for circulating glass in a container. R. W. CANFIELD (Hartford-Empire Co.). U. S. 2,230,608, Feb. 4, 1941 (Aug. 25, 1938).

Apparatus for producing five-sided closed hollow brick. JOSEF SCHOLZE. Ger. 687,667, Jan. 11, 1940 (April 10, 1935); VI/80*a*. 43.10. D.A.B.

Article tipover signal for lehrs. C. F. BIRD (Hartford-Empire Co.). U. S. 2,230,606, Feb. 4, 1941 (Nov. 9, 1938).

Conveyers for conveying glass bottles and other forms of glassware. UNITED GLASS BOTTLE MANUFACTURERS, LTD., AND E. P. DORMAN. Brit. 530,088, Dec. 18, 1940 (June 16, 1939).

Electric furnace with radiating resistances. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Brit. 531,881, Jan. 22, 1941 (Sept. 7, 1938).

Electric melting furnaces intended particularly for the manufacture of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Brit. 531,880, Jan. 22, 1941 (Sept. 17, 1938).

Fiber glass producing apparatus. H. K. MARTIN (Fiberglas Canada, Ltd.). Can. 393,519, Dec. 31, 1940 (July 26, 1938; in U. S. Oct. 21, 1937). G.M.H.

Fibrous article. R. C. NEWMAN AND J. W. ROMIG (Owens-Corning Fiberglas Corp.). U. S. 2,231,815, Feb. 11, 1941 (Aug. 25, 1937; Oct. 26, 1939).

Fibrous glass textile material. E. B. SHAND AND J. F. HYDE (Fiberglas Canada, Ltd.). Can. 393,520, Dec. 31, 1940 (Jan. 7, 1939; in U. S. Jan. 21, 1938). G.M.H.

Frame for supporting glass sheets during tempering. A. QUENTIN. Brit. 531,674, Jan. 22, 1941 (Aug. 2, 1938).

Furnace for fusing glass. MAURICE DESCARSIN. Ger. 685,686, Nov. 30, 1939 (Dec. 11, 1936); VI/32*a*. 4.—Glass and similar charges are fused by dielectric discharges into the mass placed in a crucible of refractory material. This crucible is located between two condenser plates connected with a source of high-frequency current; it is of tubular shape, being especially suited for the production of tubes, and the two condensers are so fixed that one is against the external circumference and the other is against the inner lining of the tubular crucible. D.A.B.

Furnace for use in connection with machines for the manufacture of glass articles. W. B. MITCHELL. U. S. 2,231,770, Feb. 11, 1941 (June 30, 1937).

Fusing difficultly fusible substances such as SiO_2. GEORG ZOTOS. Ger. 678,561, June 22, 1939 (Dec. 4, 1935); VI/32*a*. 35.—By means of a rotary tubular furnace, in which the speed of rotation of the furnace drum is so high that the molten mass is practically uniformly distributed over the inner surface of the drum, the melting down of the mass is brought about by a flame penetrating through the interior of the furnace. The speed of rotation of the furnace is such that the pressure exerted on the melting charge, being brought about by centrifugal force, is sufficient to prevent the volatilization of the charge. D.A.B.

Gastight seals whereby electric conductors pass into a vitreous envelope. GENERAL ELECTRIC CO., LTD., R. L. BREADNER, AND V. J. FRANCIS. Brit. 531,116, Jan. 8, 1941 (July 12, 1939).

Glass batch and decolorizing agent therefor. A. K. LYLE (Hartford-Empire Co.). U. S. 2,229,416, Jan. 21, 1941 (Aug. 25, 1938).—A decolorizer for glass batch comprises lead selenide and cobalt oxide.

Glass-drawing apparatus. ERNEST DELACUVELLERIE. U. S. 2,231,857, Feb. 11, 1941 (Jan. 8, 1937).

Glass filament producing apparatus. WILLIAM J. WOODS (Fiberglas Canada, Ltd.). Can. 393,518, Dec. 31, 1940 (April 20, 1938; in U. S. April 22, 1937). G.M.H.

Glass manufacture. F. J. DOBROVOLNY (E. I. du Pont de Nemours & Co.). U. S. 2,230,199, Jan. 28, 1941 (Jan. 14, 1937).—A process for making ruby glass comprises fusing together a mixture containing siliceous material, alkali metal monoxide, and material containing cadmium, sulfur, and selenium.

Glass sheet bending apparatus. LLOYD V. BLACK AND GERALD Z. MINTON (Pittsburgh Plate Glass Co.). Can. 393,549, Dec. 31, 1940 (May 3, 1939). G.M.H.

Grinding lenses. BAUSCH & LOMB OPTICAL CO. Ger. 680,310, Aug. 3, 1939 (Feb. 17, 1936); XII/67*a*. 19. D.A.B.

Heat-insulating material. J. H. PLUMMER (Fiberglas Canada, Ltd.). Can. 393,726, Jan. 7, 1941 (Oct. 7, 1937). G.M.H.

Hermetically sealing the inner wall of a refractory air bell. PETER KUCERA (Hartford-Empire Co.). U. S. 2,230,597, Feb. 4, 1941 (July 23, 1938).

Improving the electric-insulation resistance of glass wool or glass fibers. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 531,624, Jan. 22, 1941 (July 8, 1938).

Laminated glass. ROWLAND HILL (Imperial Chemical Industries, Ltd.). U. S. 2,231,471, Feb. 11, 1941 (May 3, 1938; Nov. 16, 1939). ADOLF WEIHE AND ARTHUR VOSS (General Aniline & Film Corp.). U. S. 2,229,781, Jan. 28, 1941 (June 6, 1939).

Low-temperature insulating material. GAMES SLAYTER (Fiberglas Canada, Ltd.). Can. 393,727, Jan. 7, 1941 (Oct. 7, 1937). G.M.H.

Manufacture of glass. E. I. DU PONT DE NEMOURS & Co. Brit. 530,644, Jan. 1, 1941 (July 21, 1938).

Manufacturing glass. G. J. BAIR (N. S. Garbisch). U. S. 2,230,343, Feb. 4, 1941 (Dec. 16, 1937).—A process of manufacturing glass comprises heating a mixture of finely divided glass and silica obtained from the grinding of plate glass to a temperature sufficient only to sinter the glass, thereby forming porous, friable agglomerates, subsequently mixing the agglomerates with soda ash and other glassforming ingredients, and melting the mixture down to form glass.

Means for stacking or feeding articles, such as glassware, into annealing lehrs, furnaces, etc. BRITISH HARTFORD-FAIRMONT SYNDICATE, LTD., AND A. LAWSON. Brit. 529,976, Dec. 18, 1940 (May 25, 1939).

Method and apparatus for making glass wool. R. H. BARNARD. U. S. 2,229,489, Jan. 21, 1941 (June 14, 1939).

Method and apparatus for the production by pressure molding of glass bodies provided with current leads. EGYESÜLT IZZÓLÁMPA ÉS VILLAMOSSÁGI RESZVENYTARSASAG. Brit. 530,275, Dec. 18, 1940 (June 20, 1938).

Method and means of heat protection for metal-to-glass seals. L. C. GOODALE (Federal Telegraph Co.). U. S. 2,229,734, Jan. 28, 1941 (June 8, 1940).

Method and means for improving the durability of glass containers. UNITED GLASS BOTTLE MANUFACTURERS, LTD., A. BUNCE, AND E. P. DORMAN. Brit. 531,145, Jan. 8, 1941 (July 13, 1939).

Nozzle for drawing sheet glass. GUSTAV OPPERMANN (Vereinigte Vopelius'sche und Wentzel'sche Glashütten G. m. b. H.). Ger. 678,655, June 29, 1939 (Aug. 16, 1937); VI/32*a*. 23.01; addition to Ger. 636,474 ("Debiteuse . . . ," *Ceram. Abs.*, **16** [8] 243 (1937)).—This nozzle consists of an upper and a lower resolvable part containing the feed opening in the one lengthwise-running side surface through which the glass enters the nozzle components. D.A.B.

Ornamental electric-light bulb and method of manufacture. H. A. ROGERS AND A. J. WOJTA. U. S. 2,231,481, Feb. 11, 1941 (Sept. 8, 1938).

Primary irons for glassmakers. MARTIN KRETSCHMER. Ger. 687,565, Jan. 11, 1940 (Oct. 18, 1938); VI/32*a*. 7.—The bulb head is hollow, and its hollow space has access to the exterior air by means of two channels running within the shaft. D.A.B.

Process and apparatus for bending glass sheets. A. H. STEVENS (Pittsburgh Plate Glass Co.). Brit. 531,515, Jan. 15, 1941 (July 25, 1939).

Producing colored and transparent glass wall plates. BRUNO E. GROSSMANN. Ger. 687,345, Jan. 4, 1940 (Feb. 14, 1938); VI/80*b*. 14.02; addition to Ger. 665,492 (*Ceram. Abs.*, **18** [6] 154 (1939)).—In a method for pro-

ducing colored and transparent glass wall plates which can be joined by mortar, two or more mat or smooth, uniformly treated, glass plates are coated with an ethereal resinous solution containing SiO_2, allowed to dry, placed on top of each other, and joined to form a single plate. D.A.B.

Producing combined asbestos and glass-fiber yarns. D. C. SIMPSON (Owens-Corning Fiberglas Corp.). U. S. 2,230,271, Feb. 4, 1941 (May 22, 1937; Aug. 24, 1938).

Producing drop bottles. CARL SCHNUERLE. Ger. 679,893, July 27, 1939 (Feb. 6, 1937); VI/32*a*. 15; addition to Ger. 658,752, March 24, 1938. D.A.B.

Producing glass articles, especially sheet glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Ger. 678,339, June 22, 1939 (April 27, 1935); VI/32*a*. 30.—Glass articles, especially sheet glass, are so hardened that zones of proportionately stronger hardness alternate with zones of lesser or no hardness. The glass article is first heated up, and then, by abrupt cooling, a uniform hardening of the entire article takes place; the article is reheated in the zones where the lesser degree of hardness is desired until the temperature is obtained where the glass expands, care being taken not to exceed this temperature; after this treatment, the article is slowly cooled down. D.A.B.

Producing glass fibers. GAMES SLAYTER (Owens-Corning Fiberglas Corp.). U. S. 2,230,272, Feb. 4, 1941 (Aug. 4, 1938).

Producing hollow glass objects, especially building blocks, consisting of single parts. J. R. HOGE, L. D. SOUBIER, L. O. MANKIN, AND B. F. HAZELTON, JR. (A.-G. der Gerresheimer Glashüttenwerke vorm. Ferd. Heye). Ger. 687,651, Jan. 11, 1940 (Sept. 11, 1937); VI/32*a*. 24.04.—The parts to be joined have their edges brought into exact fitting contact, and the edges are heated, while being turned, by means of one or more burners; with further turning, bands or strips of molten glass are applied to the edges to bind the parts together. D.A.B.

Producing mineral wool. R. C. JOHNSON AND H. J. ROSE (Anthracite Industries, Inc.). U. S. 2,229,974, Jan. 28, 1941 (Sept. 30, 1938).

Producing shatterproof compound glass. ADOLF KÄMPFER. Ger. 687,486, Jan. 4, 1940 (Nov. 13, 1934); IV*c*/39*b*. 27.—A method is given for producing shatterproof compound glass by employing a nonsplitting intermediate layer of polyvinyl acetate and an added softening agent. The vinyl acetate, polymerized to the end point, is pulverized and, at a higher temperature, is mixed with the softening agent. A mixture of the polymerized vinyl acetate and 30% softening agent is heated to 120° to 140°C. and then, under high pressure, is injected into the final plate form, whereupon the intermediate layer thus obtained is joined with the glass plates. D.A.B.

Production of fibers of glass, etc. ALGEMEENE KUNSTVEZEL MIJ. N. V. Brit. 530,468, Dec. 26, 1940 (June 25, 1938).

Production of glassware. WÜRTTEMBERGISCHE METALLWARENFABRIK AND K. WIEDMANN. Brit. 530,343, Dec. 26, 1940 (June 21, 1939).

Production of inlaid glasses. WÜRTTEMBERGISCHE METALLWARENFABRIK. Ger. 674,546, March 30, 1939 (Feb. 8, 1937); VI/32*a*. 8.—In a method for producing inlaid glasses, an inner glass object or body is surrounded by external broken or cut glass bodies which are fastened to the wall of the inner glass object or body by glass stays. A hollow double walled glass object is produced first, and bar-shaped pieces of glass are then pushed through the exterior or interior wall while the glass object is in the fused state or after the places where the stays are to be placed have been locally heated up until they adhere to the opposite wall. The remainder of the glass stay extending on the outside is removed, and, if desired, the outer wall joined to the interior by the glass stays is treated by sandblasting, grinding, boring, or etching; the glass object is finally subjected to a finer fabrication. D.A.B.

Protecting glassmelting furnaces, glass troughs, etc. EBERHARD KEETMANN. Ger. 687,997, Jan. 18, 1940 (Oct. 12, 1935); VI/80*b*. 8.15.—A method is given for protecting glass furnaces, etc., in which the walls of the glass furnace, trough, etc., which are subjected to the attack of the fluid glass are coated with a glazelike poreless protective layer. The parts of the walls to be protected are coated with a nonrefractory, glazelike layer by the usual methods used in ceramic glazing, viz., dipping, moistening or wetting, and spraying of the wall units with the crude finely ground water-insoluble glaze slip suspended in a liquid. This layer, in comparison with the glazes on ordinary ceramic articles, has an excessive content of viscosity-increasing admixtures such as Al_2O_3, ZrO_2, etc. D.A.B.

Readily fusible glasses free from silicon. PATENTVERWERTUNGS-GES. HERMES. Brit. 531,665, Jan. 22, 1941 (July 28, 1938).

Sealing into glass of objects consisting of tungsten. PHILIPS LAMPS, LTD. Brit. 531,688, Jan. 22, 1941 (July 4, 1938).

Sealing molybdenum members into glass. PHILIPS LAMPS, LTD. Brit. 531,823, Jan. 22, 1941 (July 7, 1938).

Shaping ophthalmic lenses. H. R. MOULTON (American Optical Co.). U. S. 2,230,118, Jan. 28, 1941 (Sept. 2, 1937).

Spray mechanism for glass machinery. M. M. CANNON, JR. (Hartford-Empire Co.). U. S. 2,230,609, Feb. 4, 1941 (Dec. 31, 1938).

Strand- or thread-winding mechanism. J. H. THOMAS AND ED. FLETCHER (Fiberglas Canada, Ltd.). Can. 393,728, Jan. 7, 1941 (Aug. 26, 1938; in U. S. Aug. 28, 1937). G.M.H.

Tempered glass article. J. T. LITTLETON, W. W. SHAVER, AND H. R. LILLIE (Corning Glass Works). U. S. 2,231,811, Feb. 11, 1941 (Sept. 24, 1935).

Utilizing waste sand resulting after glass grinding. GEORGE BAIR (N. S. Garbisch). Ger. 687,157, Dec. 28, 1939 (Dec. 14, 1938); VI/32*b*. 1.—The sand is heated up to such a temperature that the fine particles of sand fuse together to form large agglomerations. This product is then ground to obtain a uniform particle size. D.A.B.

Wall construction. S. F. COX AND P. E. KNUDSEN (Pittsburgh Plate Glass Co.). U. S. 2,230,348, Feb. 4, 1941 (June 17, 1938).

Structural Clay Products

Effect of repeated wetting and drying on physical properties of a clay body. W. R. MORGAN. *Jour. Amer. Ceram. Soc.*, **24** [3] 84–88 (1941).

Extrusion problems in brickworks. F. W. JOLLY. *Claycraft*, **13** [7] 193–98 (1940).—J. discusses various plant problems arising from the extrusion of clay through a die. Friction in the mouthpiece and the subsequent cracking of the ware due to uneven flow of the clay was overcome by (1) lengthening the mouthpiece and providing an equal taper all the way through and (2) lubrication of the mouthpiece and of the die. Lubrication was accomplished by boring out the back of the mouthpiece to take an angle iron ring, machined all over to make it oilproof and clayproof. In the mouthpiece, oil grooves $^1/_8$ in. deep were cut about $^1/_2$ in. apart and for about 4 in. down the casting all the way around. On the angle ring is riveted a ring of sheet steel, 16s or 18s gauge, which is cut and beaten out to conform with the altered shape of the mouthpiece further down. The cuts are then welded so that no clay can get into the oil grooves. An oil pipe is fitted to the top of the mouthpiece connected to a small oil pump, and a drain is fitted at the bottom. J. also discusses the correction of uneven flow through the dies on the vertical type of extrusion machine by means of a retarder

for both hollow block dies and crested ridge dies. Drawings show the various types of die trouble and remedies for them. G.A.K.

Measuring the cumulative power of plasticizing and extruding stiff-mud shapes. H. R. STRAIGHT. *Bull. Amer. Ceram. Soc.*, **20** [2] 48–50 (1941).—4 references.

Properties of the pore system in brick and their relation to frost action. RAY T. STULL AND PAUL V. JOHNSON. *Jour. Research Nat. Bur. Standards*, **25** [6] 711–30 (1940); RP 1349. Price 10¢.—In the study of certain properties of the pore system in brick and their relation to frost action, the authors reached the following conclusions: (1) The variation in porosity of individual brick is one measure of their lack of uniform structure and may affect their resistance to frost action. (2) There is no definite correlation of the location of the lowest, medium, and highest porosities of the sections among the brick tested. The differences between maximum and minimum percentage porosities of the different sections of the individual brick ranged from 11.6 to 48.42%. (3) When the air permeabilities of two brick are f_1 and f_2 and their respective thicknesses are T_1 and T_2, then the air transmission, or air conductance, F, of the two brick in series may be calculated by the equation $F = \frac{f_1 f_2}{f_1 T_2 + f_2 T_1}$. The differences between the calculated and experimental values for F were so small as to be negligible. (4) The average values of the data for brick of four of the eight series tested indicate that the mean effective capillary radius, the permeability, and the number of cycles of freezing and thawing at which the brick fail increase and the number of capillaries, pore volume, and initial saturation coefficient decrease as the firing temperature of the brick is increased. (5) The decrease in pore volume and number of pores as the firing temperature is increased indicates that some of the pores have become filled or sealed and therefore inactive in regard to permeability and absorption. An increase in mean effective capillary radius and permeability, accompanied by a decrease in the number of pores, indicates that the pores rendered inactive were chiefly the smaller ones originally occurring as microcavities formed by the microparticles. The increase in permeability with the firing temperature must, therefore, result from an enlargement of the larger connecting pore openings, which may be due to partial fusion and receding of the angular edges of the openings between adjacent pores. (6) The air permeabilities were constant with respect to time of flow whereas the water permeabilities varied, increasing for those brick whose mean effective capillary radii were less than 2 microns and decreasing for those whose radii were greater than 2 microns. (7) The saturation coefficients increased with increase in the number of freezing and thawing cycles, and the graph representing the plot of the two variables can be represented fairly well by an equation of a hyperbola of the form $S = a - \frac{K}{b + C}$, where C = the cycle number of freezing and thawing, S = the corresponding saturation coefficient, and a, b, and K are constants for a definite brick but are different for different brick. The constant a indicates that there is an upper limiting value of S for a brick, assuming that the brick would withstand (theoretically) an infinite number of freezing and thawing cycles. (8) Repeated freezing and thawing (by immersion) of some brick may increase their saturation coefficients to values greater than unity, thus indicating that they contain volumes of water larger than their original pore volumes. (9) In brick substantially free from defects, data indicate that the number of cycles of freezing and thawing to cause failure increases when the air permeability and mean effective capillary radius increase and when the saturation, porosity, and number of capillaries decrease. R.A.H.

Rational design of load-bearing brickwork. ANON. *Claycraft*, **13** [12] 352–53 (1940).—A series of easily read charts is described; these give the actual practical answer to any specific problem which may arise in the design of load-bearing brickwork in accordance with building regulations. Maximum permissible loads for story heights up to 24 ft. for walls and 18 ft. for columns are given inch by inch; wall thicknesses and column dimensions up to 18 in. and loads up to 36 tons are also given. Five typical examples illustrate the use of the charts. Copies of the charts may be obtained from the Clay Products Technical Bureau of Great Britain, Ltd., 90 Ebury St., London, S. W. 1, England. The price is 1s. G.A.K.

SEPARATE PUBLICATION

Effects of Wetting and Drying on the Permeability of Masonry Walls. CYRUS C. FISHBURN. *Nat. Bur. Standards Bldg. Materials & Structures Rept.*, BMS55, 6 pp. (Sept., 1940). Price 10¢.—Since the volume changes resulting from the wetting and drying of masonry units and mortars are unequal, changes in the moisture content of a masonry wall may produce differential volume changes between the units and the mortar, resulting in the formation or enlargement of cracks in the joints. The effects of changes in the moisture content of eight small masonry walls were studied by measuring the permeability of the walls during each of about 12 cycles of wetting and drying. The walls were wetted by applying water to the exposed face simulating an exposure to a wind-driven rain. The specimens were not subjected to freezing during wetting or drying. Five of the walls were of all-brick construction, one was a stucco-faced wall, and two were faced with brick and backed with hollow units. There was no significant change in the permeability of the walls resulting from the exposure to wetting and drying. R.A.H.

PATENTS

Ceramic product. G. W. REED. U. S. 2,230,309, Feb. 4, 1941 (June 4, 1938).—A ceramic building unit.

Hollow-tile flooring for beam grids. E. MAIER. Brit. 530,486, Dec. 26, 1940 (June 26, 1939).

Vitreous clay underground conduit. A. P. MCDONALD. U. S. 2,230,306, Feb. 4, 1941 (Jan. 19, 1939).

Refractories

Alumina production from domestic materials. F. L. SCHMIDT. *Chem.-Ztg.*, **63** [82–83] 661–62 (1939).—Sources of German clays and their compositions and uses, especially in cement production, are described. D.A.B.

Aluminum from clay. ANON. *Manchester Guardian Commercial*, **37** [954] 345 (1938).—A German aluminum producer has set up a factory which produces 8000 tons of aluminum per year from domestic clay. This confirms the conclusion deduced from laboratory experiments covering 18 months. F.J.H.

Behavior of silica brick in metallurgical furnaces. YVES LETORT. *Arts du Feu*, **2**, 174–80 (1939); *Chem. Abs.*, **33**, 8941 (1939).—Silica brick forms four zones during firing: a clear and untransformed zone, a brown zone composed of tridymite crystals, a black zone also of tridymite but in enormous crystals with Fe, and a final gray zone formed entirely of cristobalite because of the action of high temperature. The thermal resistance of the different zones is more clearly ascertained.

Cementing of the troughs of the Martin furnace and the question of siphon brick in the bottom plate. L. O. SOKILOVSKII. *Teoriya & Prakt. Met.*, **10** [1] 36–38 (1938); *Chem. Zentr.*, **1939, I**, 219; *Chem. Abs.*, **34**, 6783 (1940).—Various mixtures are recommended for cementing the gutter of the Martin furnace: (1) grog 80, fire clay 18, and dextrin 2%; (2) (grain size 0.5 to 2 mm.) grog 77, fire clay 18, and sirup 5%; (3) grog fragments 67, fire clay 17, and coke dust 16%. The following mixtures are recommended for laying the siphon brick: (1) sand 65,

graphite 26, calcined Na_2CO_3 1, and water glass 8%; (2) fire clay 31, sand 66, and sulfide liquor 3%.

Choice of material for the floor of a preheating furnace for heating material to be rolled. A. I. KRAMARENKO. *Metallurg*, **13** [9] 83–94 (1938); *Chem. Zentr.*, **1939, I**, 1826; *Chem. Abs.*, **34**, 7559 (1940).—The mill scale is strongly aggressive to semiacid or chamotte materials. Chamotte which is fireproof up to 1460° should be used, therefore, or supporting rails should be laid in the furnace. Of the basic materials, chromite, talc, and concrete materials or mixtures are to be considered. The influence of the material of the furnace floor on the character of the mill scale is discussed as are also means of leveling uneven portions of the furnace floor. See "Selection. . . ," *Ceram. Abs.*, **19** [3] 68 (1940).

Chromium ore: III, Degree of oxidation of iron in chromium ore. K. KONOPICKY AND F. CAESAR. *Ber. Deut. Keram. Ges.*, **20** [8] 367–73 (1939).—The FeO content of the chromium ore is easily oxidized even at temperatures of about 300°C. The ratio FeO/Fe_2O_3 in the chromium ore depends, therefore, on the accidental conditions of its origin and occurrence. There is no reason for trying to force the compositions of chromium ores into a formula. The Fe_2O_3 formed by oxidation of the chromium ore causes an increased solubility in hydrochloric acid. Chromium ore, when oxidized, becomes poorer in bases and richer in sesquioxides. On firing, therefore, it is able to take up MgO and is improved by this addition but not by the change of serpentine into forsterite, which for the most part proceeds proportionately. The low softening point of chromium ore is due to the Fe_2O_3 formed on firing. If this Fe_2O_3 is neutralized by MgO, the softening point is markedly increased (by about 150°). For Part II see this issue, p. 104. W.H.H.

Determining thermal conductivity at high temperatures. C. DINGER, A. KIND, W. SCHUTZ, AND A. DIETZEL. *Ber. Deut. Keram. Ges.*, **20** [8] 347–62 (1939).—An instrument is described which permits, sufficiently accurately and quickly, the measurement of the coefficient of heat conductivity of refractory materials up to about 1400°C. The fundamental principle of the method is the use of a hollow cylinder heated from within with calorimetric measurement of the energy outside. The cylinder is composed of 7 or 8 disks of the test material, placed one above the other and bored through the center for the insertion of the heating element. This consists of a rod of carbon surrounded by powdered coal and placed in a tube of sillimanite. The tube is closed by specially designed graphite valves. Around the hollow cylinder made up of the test pieces lies the water calorimeter. This consists of two compartments connected by a spiral passage which serves to measure the flow of water. The temperature of the water is indicated at the entrance and the outlet by thermometers reading to 1/100°. To measure the inner and outer temperatures, the hollow column of test pieces carries, parallel to its axis, on the inner and outer surfaces, fine grooves in which lie a Pt-Pt Rh thermocouple on the inside and a Ni-Ni Cr thermocouple on the outside. A calculation of the sources of error shows that the relation of the radii of the cylinder has a very marked effect on the accuracy obtained; insufficient attention was paid to this in the previous hollow-cylinder method. In the present case the ratio of the outer cylinder radius to the inner cylinder radius equals 4; the possible error in measuring the radii could cause an error of at most 1.4%. Average values of the coefficient of heat conductivity are determined for several temperature intervals, and the true values are obtained from them by calculation. The deviation of the calculated temperature curve from the true temperature curve may be accurately calculated by a summation equation which is given. The most probable error is 3.5%. The actual measurement up to 1400° inside temperature requires about a day. The maximum temperature can, without change of arrangement, be extended to about 1600°C. W.H.H.

Dominion can supply Canadian steel mills all necessary refractory products. ANON. *Can. Machinery*, **50** [11] 35, 55 (1939).—Canadian magnesitic dolomite now replaces the cut-off European supply of magnesite from Austria and Greece. Resources have been developed together with research, new products, and apparatus. Mining has improved from open quarry pit methods to practical underground-mine methods. Improvements have also been made in the production of clinkered magnesite; this process is discussed. The refractory industry has branched into the basic-brick field, using dead-burned magnesitic dolomite as a base and chrome ore for fired chrome brick. A pure magnesia brick has recently been developed by utilizing Canadian deposits of brucite ($Mg[OH]_2$) which is of major interest to the copper and nickel producers for the refractory construction of reverberatory, converter, and refining furnaces. Arrangements have been made for the United Kingdom and the U. S. to take advantage of refractory patents and processes in respect to licensing. See "Basic . . .," *Ceram. Abs.*, **19** [6] 140 (1940). D.A.B.

Effect of the chief production factors on the properties of high grog products. R. T. MAKHL AND R. I. ROZENBERG. *Keram. Sbornik*, **1939**, No. 1, pp. 27–36.—The effect of the following factors on the properties of high-grog bodies was determined: (1) coarseness of the grog, (2) temperature of firing of grog and bodies, (3) quantity of bonding clay, (4) nature of clay and grog, and (5) pressure. Among these factors, low-fired grog has the strongest effect, but it cannot be used for high-grog products because of its great shrinkage (up to 12%). The coarseness of the grain and the nature of the raw material have considerable influence. The temperature of firing is not as important in high-grog bodies as in bodies produced by the usual methods. M.V.C.

Examination of glass tank block refractories by X-ray methods. H. P. ROOKSBY AND J. H. PARTRIDGE. *Jour. Soc. Glass Tech.*, **24** [103] 109–23 (1940).—An account is given of the technique of the X-ray powder method of analysis in its application to the study of glass tank block refractories. The properties of materials revealed by the method, relevant to the examination of refractories, are discussed, together with the identification of the different phases present, the distinction between the crystal forms of silica, and the measurement of the crystal size and purity of the mullite component. One of the objects of the X-ray analysis is to determine whether the firing treatment of tank blocks has been sufficient to produce the structure required for present-day glassmelting tanks. The state of crystallization of the mullite is a more reliable guide to the efficacy of firing than the absence of the low-temperature form of free silica. The results of examinations of a large number of commercial brick, both clay and sillimanite, from various sources are described. Their structures are compared with those of specimens which have been refired in the laboratory at 1430° to 1450°. The use of fluxes and the presence of black cores in tank blocks are referred to. G.R.S.

Fusion of raw phosphates and soda slag. KARL H. HENNENBERGER. *Stahl & Eisen*, **59** [22] 662–63 (1939).—H. discusses the use of soda slag in the manufacture of phosphate fertilizer. Difficulties were encountered in obtaining an oven lining which would not readily dissolve in the melt. Tar dolomite is best. A graphical flow diagram shows how Röchling phosphate is made. J.P.S.

Hardening of aluminous cement at high and low temperatures. STEVEN GOTTLIEB. *Cement & Lime Manuf.*, **13** [4] 55–60 (1940).—G. describes concrete works successfully carried out at temperatures as low as 0°F. and gives the results of tests on the hardening of aluminous cement at high temperatures. G.R.S.

Magnesia brick for lining cement kilns. STEVEN GOTTLIEB. *Cement & Lime Manuf.*, **13** [2] 19–21 (1940).—The laboratory tests, in which the composition of the raw materials fluctuated considerably, were carried out to examine the reaction of these raw materials with various refractory brick, particularly high-alumina, magnesia, and clay brick (with about 40% Al_2O_3). Chemical composition (lime saturation value, silica and iron moduli, and ash content) and the fineness of the raw meal were systematically

varied. With these varying factors, no reaction could be found on the surface of the magnesia brick. In the case of raw meals which were clinkered under testing conditions, the clay brick showed strong adherence, and much molten material was formed between the clinker and the brick; this penetrated into the clinker and into the brick. The higher the ash content and the lower the silica and iron moduli and the lime saturation value, the stronger was this effect. With high-alumina brick (60 to 70% Al_2O_3), the reaction between brick and clinker started at higher temperatures, and although less molten material was produced it stuck faster to the surface of the brick than in the case of the clay brick. Under normal firing conditions, the high-magnesia brick in rotary kilns is not sensitive to fluctuations of the chemical composition and ash content. Several years' observations are given on the behavior of high-magnesia, alumina, and clay brick in automatic shaft kilns. G.R.S.

Magnesite refractories in Canada. ANON. *Can. Metals Met. Inds.*, **3**, 251 (1940).—The Canadian position with respect to magnesitic basic refractories has improved, but Canada is not yet self-sufficient in refractories and should survey the situation to prevent a bottle-neck in refractory supplies. See "Basic . . . ," *Ceram. Abs.*, **19** [6] 140 (1940). E.P.

Monolithic linings for cupolas. F. OLDERSHAW, MACCOLL, AND FORREST. *Foundry Trade Jour.*, **62** [1222] 63–64 (1940).—Hints are given for the successful operation of monolithic linings, covering construction details, drying times, expansion voids, and general care. Comparative runs with similar cupolas showed that monolithic linings had a longer life than regular brick linings. See "Practical . . .," *Ceram. Abs.*, **20** [1] 18 (1941). H.E.S.

Possible improvements in firebrick quality. CHRISTOPHER E. MOORE. *Claycraft*, **14** [3] 81–82 (1940).—M. discusses the improvement of the quality of firebrick by (*a*) more careful selection of clay at the pit, (*b*) weathering and aging, (*c*) finer grinding, and (*d*) harder firing. G.A.K.

Preparation of fire clays for manufacture by the plastic process. L. J. SYKES. *Claycraft*, **13** [6] 167–72 (1940).—The correct quantities of rough, medium, and fine clay and the correct percentage of the correct gradings of grog are important points in the manufacture of fire-clay goods. S. discusses control of materials, grinding mill, feeders, elevators, screening, grog, storage, mixing and tempering process, and forming of the clay. He concludes that the first aim in the preparation process is absolute control of the materials used in any operation. By grinding and screening each material separately, the size and the shape of the grains are controlled. By storing each material separately, definite control is obtained for both quantity and type. G.A.K.

Refractories for cement kilns. HENRY G. FISK. *Cement & Lime Manuf.*, **13** [1] 13–18; [3] 51–54; [4] 74–76 (1940).—Bibliography and abstracts for the years 1913 to 1938 are given. G.R.S.

Refractory concretes. Influence of method of preparation. M. LÉPINGLE. *Chimie & Industrie*, **43** [9] 713–16 (1940); *Trans. Brit. Ceram. Soc.*, **39** [8] 74A (1940).—A study has been made of the effects on the mechanical strength of refractory concrete and its behavior at high temperatures of a number of factors such as the method of preparation, the cement mixing, method of introducing the water, the addition of mullite powder, and the replacement of *ciment fondu* by monocalcium aluminate. The types of grog used were silicoaluminous (30 to 32% alumina) grog and highly calcined mullite, and the hydraulic bonds used were *ciment fondu* and monocalcium aluminate. Manufacturing methods (mechanical pressing, shaking, tamping, etc.) had little influence on the behavior at high temperatures. The refractoriness under load was directly affected by the chemical composition; the effect of the cement mixing ratio was reflected in favor of the "shorter" concretes. With regard to the method of introducing water, the results favor current practice; simply saturating the grog with water did not give good results. The effect of powdered mullite additions was favorable, especially on concrete made by the shaking method. The results in general indicate the importance of the chemical composition of the grog used and the composition of the bond; the relative proportions of fusible impurities in the concrete should be reduced as much as possible. The shaking method of preparation is recommended in preference to tamping and mechanical pressing.

Refractory requirements for the electric smelting of iron ores. CHARLES HART. *Bull. Amer. Ceram. Soc.*, **20** [2] 53–56 (1941).—4 figures.

Repairing materials for refractory brickwork. P. H. WIJTMAN. *Arch. Suikerind.*, **1**, 179–82 (1940); *Brit. Chem. & Phys. Abs.-B*, **59** [11] 800 (1940).—"Plibrico," a plastic for repairing firebrick structures, consists of H_2O (9.2), chamotte (57.3), and refractory clay (33.4%), the last two containing SiO_2 (55.2, 57.0), Al_2O_3 (40.4, 31.8), Fe_2O_3 (3.0, 2.5), CaO (0.3, 0.1), MgO (1.1, 0.8), SO_3 (0.2, 0.3), and volatile matter (0.4, 8.9%), respectively. It is satisfactory for ampas fires and lime kilns.

Special brick necessary in wartime: III, Chromite refractories. IV, Chrome-magnesite refractories. JOSEF ROBITSCHEK AND FELIX SINGER. *Brit. Clayworker*, **48** [573] 310–14; [574] 333–38 (1940).—The chemical analyses of commercial chrome ores and imports from various sources to Great Britain are given. The manufacture of chromite refractories, including mortars and ramming compositions, is briefly discussed. A decisive improvement of the technically important properties of chromite refractories cannot be expected unless steps are taken to alter the mineralogical constitution of the ore and of the final product so as to convert it into a chrome-magnesite or a chrome-spinel product. The manufacture and properties of both fired and unfired chrome-magnesite brick are discussed. The trend of future developments is toward the replacement of silica refractories in basic steel and copper-smelting furnaces by basic refractories because of their greater refractoriness. For Parts I and II see "Magnesite . . .," *Ceram. Abs.*, **18** [9] 245 (1939); "Water . . .," *ibid.*, **19** [1] 17 (1940). R.A.H.

Technical Congress of the Ceramic Industry of France, Paris, June, 1939. ANON. *Métallurgie*, **71** [13] 9–16 (1939). J.M.N.

Use of special magnesia brick in the cement industry. F. KREMER. *Rev. Matériaux Construction Trav. Publics*, **1939**, 137–40; *Chem. Abs.*, **34**, 4879 (1940).—The newer types of MgO brick overcome the difficulties of high thermal expansion, and, as the loss of MgO to the charge is negligible, they form an almost ideal lining for the firing zone of a rotary kiln.

SEPARATE PUBLICATIONS

Development of Superduty Refractories from Ohio, Pennsylvania, and Kentucky Fire Clays. RALSTON RUSSELL, JR. *Ohio State Univ. Eng. Expt. Sta. Bull.*, No. 105, 81 pp. (1940).—A superduty refractory must have a P.C.E. of at least 33, a reheat shrinkage of not over 1%, and a spalling loss of not over 4%. Deposits of such clays are not extensive in these states. Thirteen different fire clays were tested. They were sized to give three fractions, 8 to 20 mesh, 20 to 65 mesh, and through 65 mesh. The composition selected as standard consisted of coarse 45%, intermediate 15%, and fine fraction 40%. The clays were mixed dry, a 5% dextrin solution was used to add 5 to 7% water, and the whole was mixed carefully. The dry-press method was used in forming, and the pressure was applied and released in the stages of 800, 3500, and 4000 lb. per sq. in. The clays were fired in a commercial periodic kiln firing refractories at cones 11 to 12 or 17 to 18. Tests were made on P.C.E., compaction of unfired dry mix, firing shrinkage, absorption and porosity, fired bulk density, transverse strength, reheat shrinkage, load, panel spalling, and linear thermal expansion. A polished section was examined. The use of calcined clay may reduce shrinkage, although the strength and density may also drop. Small amounts of feldspar, boric acid, aluminum sulfate, and sodium aluminum silicate were added. The aluminum sulfate decreased shrinkage, transverse strength, and density; the other additions had little effect.

To improve the P.C.E. of cone 32½ clay, R. studied the effect of adding calcined alumina up to 10%, fused alumina up to 10%, alumina gel up to 20%, feldspar up to 2%, boric acid up to 1%, flint up to 10%, and kaolin up to 10%. All alumina additions improved the P.C.E., while flint and alumina gel lowered it. Aluminum sulfate was the most effective; 10% gave a P.C.E. of 33, and 20% gave a P.C.E. of 33½. Voids present after firing may be eliminated by substituting calcined clay, the amount depending on the grain size of the composition itself. Two good clays were made into 54 compositions and tested. Of these, four were used, one high in grog and three without. The three without grog cracked on firing. An addition of 8% grog to two stopped the cracking, but one of these was the only superduty refractory produced. W.D.F.

Symposium on Thermal Insulating Materials. American Society for Testing Materials, Philadelphia, 1939. 123 pp. Price, paper, $1.25; cloth, $1.50. **Introduction.** J. H. WALKER. pp. 1–2. **Factors influencing the thermal conductivity of nonmetallic materials.** J. B. AUSTIN. Pp. 3–67. 47 references. For abstract see *Ceram. Abs.*, 20 [2] 45 (1941). **Test methods for determining physical properties of plastic and preformed thermal insulations.** H. H. RINEHART. Pp. 68–85. **One consumer's problems in selecting heat insulation.** E. T. COPE AND W. F. KINNEY. Pp. 86–105.—The important problems encountered are reviewed, and test methods are briefly described. A procedure is suggested which would lead to a better understanding between producer and consumer. See "Heat . . . ," *Ceram. Abs.*, **19** [11] 258 (1940). **Effect of solar radiation on heat transmission through walls.** F. C. HOUGHTEN, CARL GUTBERLET, AND ALBERT A. ROSENBERG. Pp. 106–23.—A somewhat unusual phase of the insulation problem is dealt with. The heat flow through the walls of buildings under the influence of solar radiation is decidedly cyclic. The thermal capacity of the wall and of the insulation is, therefore, an important factor. The fundamental principles are discussed, and actual data are presented. Discussions of the papers are included. Tables and diagrams are given.

PATENTS

Calcium orthosilicate refractory and process of making. H. C. LEE (Basic Dolomite, Inc.). U. S. 2,229,297, Jan. 21, 1941 (Sept. 7, 1935).—A refractory preparation substantially consists of magnesia, silica, and lime in such proportions as to give on firing at high temperature a refractory comprising periclase granules in a calcium orthosilicate matrix.

Calcium oxide-chromium oxide refractory. G. R. POLE. U. S. 2,231,024, Feb. 11, 1941 (Nov. 21, 1938).—A pressed and fired mixture substantially consists of calcium oxide and chromium oxide in proportions corresponding approximately to a compound containing about 50 mol % of each.

Hot top. G. H. JOHNSTON. U. S. 2,229,507, Jan. 21, 1941 (June 10, 1939).

Manufacture of basic refractories. M. DOUGLAS, A. L. BRADLEY, AND J. H. CHESTERS. Brit. 530,168, Dec. 18, 1940 (June 5, 1939).

Manufacture of refractory articles. THERMAL SYNDICATE, LTD., AND G. N. PEEL. Brit. 531,676, Jan. 22, 1941 (July 29, 1939).

Metal-cased refractory. V. M. GOLDSCHMIDT. Can. 393,426, Dec. 24, 1940 (Aug. 26, 1938). G.M.H.

Producing casting forms. VICTOR KROSTA. Ger. 687,594, Jan. 11, 1940 (May 25, 1935); VI/31*c*. 1.01.—Casting forms of predetermined expansion for the casting of high melting metals and metal alloys are produced from quartz. The form is made essentially of silicon dioxide, which consists entirely or mostly of beta-quartz, and is heated up in such a manner that the quartz is transformed into alpha-tridymite or alpha-cristobalite to obtain a predetermined expansion. D.A.B.

Refractory product. H. P. HOOD (Corning Glass Works). Ger. 687,896, Jan. 18, 1940 (April 14, 1938); VI/80*b*. 8.18.—A refractory product which resists the action of molten glass consists of tin oxide (at least that part of the surface attacked by the fused glass). The product is formed and is subjected to a heat treatment. D.A.B.

Rotary kiln lining. R. P. HEUER (General Refractories Co.). U. S. 2,230,141, Jan. 28, 1941 (Oct. 24, 1939). R. E. LONGACRE (General Refractories Co.). U. S. 2,230,142, Jan. 28, 1941 (Oct. 24, 1939).

Terra Cotta

PATENTS

Design for flowerpot. HARRY RATNER. U. S. 125,058, Feb. 11, 1941 (June 14, 1940).

Irrigating flowerpot. D. P. SHOCKNEY. U. S. 2,231,300, Feb. 11, 1941 (May 1, 1939).

Machines for grading tile, etc., according to dimensions. JESSHOPE, LTD., AND A. BADDELEY. Brit. 530,469, Dec. 26, 1940 (June 24, 1939).

Means for use in making joints between earthenware pipes, etc. CLAYTON, GOODFELLOW, & Co., LTD., W. S. HARRISON, AND A. BARTON. Brit. 530,532, Dec. 26, 1940 (June 21, 1939).

Tile floor and method of producing. J. R. KAUFFMAN (Barber Asphalt Corp.). U. S. 2,229,742, Jan. 28, 1941 (Sept. 15, 1937).

Whiteware

Characteristic nature of the glaze of Japanese earthenware and porcelain. EIITI KOIZUMI. *Jour. Chem. Soc. Japan*, **60**, 1242–46 (1939); *Chem. Abs.*, **34**, 2148 (1940).—Analyses of porcelain glazes from the Kyushu district are given.

Minutes of meeting of the Whiteware Committee on Research. R. F. GELLER. *Bull. Amer. Ceram. Soc.*, 20 [2] 69–70 (1941).

Moisture expansion of ceramic whiteware in storage and in service. R. F. GELLER AND A. S. CREAMER. *Jour. Amer. Ceram. Soc.*, 24 [3] 77–79 (1941).

Porcelain bodies with lowered firing temperature. G. V. SHUTOV AND K. V. SALAZKIN. *Keram. Sbornik*, 1939, No. 1, pp. 48–55.—Telephone and telegraph insulators were fired to cone 130 to 132. The lowering of the finishing firing temperature did not affect the properties of the insulators; it permitted a decrease in firing time and improved the durability of the saggers. M.V.C.

Production of bacteriological filters. R. M. YURCHAK. *Keram. Sbornik*, 1939, No. 1, pp. 65–69.—Y. describes the properties of raw materials, methods of manufacture, firing, glazing, and possible defects of filters. M.V.C.

Reflectance measurements of typical glazed ceramic bodies. J. A. PASK. *Bull. Amer. Ceram. Soc.*, 20 [2] 50–53 (1941).—9 figures.

Thermal expansion of silicate fluxes in crystalline and glassy states. H. J. ORLOWSKI AND C. J. KOENIG. *Jour. Amer. Ceram. Soc.*, 24 [3] 80–84 (1941).

SEPARATE PUBLICATION

Westinghouse Porcelain. *Westinghouse Electric & Mfg. Co. Booklet*, No. B-2263, 16 pp. Free.—Porcelain-insulator manufacture is described by means of pictures and brief explanations, starting from the raw material stage with the quarrying of feldspar, the prime ingredient of porcelain. The accurate weighing of raw materials, the mixing of the feldspar and clay, the elimination of

impurities, the forming of the insulators by the many methods used, glazing, drying, and firing are illustrated and explained. Copies may be obtained from Dept. 8-N-48, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

PATENTS

Ceramic support. W. F. SMITH. U. S. 2,231,033, Feb. 11, 1941 (Dec. 6, 1937).—A vertically aligned assembly of a plurality of superposed fired ceramic ware support elements.

Connecting a metal body to a vitreous ceramic body. D. H. ROWLAND AND C. D. CROSKEY (Locke Insulator Corp.). U. S. 2,230,205, Jan. 28, 1941 (Oct. 24, 1939).

Design for combined lavatory and pedestal. J. M. LEWIS (Abingdon Sanitary Mfg. Co.). U. S. 125,054, Feb. 11, 1941 (July 12, 1940).

Design for lavatory. J. M. LEWIS (Abingdon Sanitary Mfg. Co.). U. S. 125,053, Feb. 11, 1941 (July 12, 1940).

Design for water closet. J. M. LEWIS (Abingdon Sanitary Mfg. Co.). U. S. 125,055, Feb. 11, 1941 (July 12, 1940).

Improving physical properties of ceramic spark-plug elements. RICHARD STRIBECK (Robert Bosch G.m.b.H.). Ger. 675,495, April 21, 1939 (July 9, 1937); I/46c³. 60.01.—A method is given for improving the properties of spark-plug elements, especially the resistivity of the element to temperature changes, by employing ceramic materials with constituents which are soluble in corrosives and materials not soluble in corrosives. The ceramic spark-plug element is superficially etched. D.A.B.

Manufacture of ceramic ware. I. E. SPROAT (R. T. Vanderbilt Co., Inc.). U. S. 2,230,206, Jan. 28, 1941 (April 14, 1938).—Ceramic bodies made from a mixture comprising flint, clay, and a zoisitic rock as herein defined.

Metallic and ceramic body. HANS PULFRICH (Canadian General Electric Co., Ltd.). Can. 393,654, Jan. 7, 1941 (July 28, 1937). Can. 393,655, Jan. 7, 1941 (Oct. 19, 1937). G.M.H.

Producing a calcined ceramic protective coating on electrodes of spark plugs. ERICH WIPPERMANN. Ger. 686,426, Dec. 14, 1939 (Feb. 11, 1938); Ia/46c³. 33.—The metal electrode is coated with a ceramic mixture and powdered tungsten at fusing temperature. D.A.B.

Spark plugs. R. A. SMITH (Breeze Corps., Inc.). Brit. 529,856, Dec. 18, 1940 (June 9, 1939).

Table hollow ware. E. T. EVERTON, LTD., AND A. T. PADMORE. Brit. 531,540, Jan. 22, 1941 (July 4, 1939).

Equipment and Apparatus

Automatic telescope control. A. C. HARDY. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 654 (1940). A.P.

Calibration data on General Electric recording spectrophotometer. J. L. MICHAELSON AND W. R. FANTER. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 656 (1940). A.P.

Change of color with change of particle size. I. H. GODLOVE. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 658 (1940). A.P.

Changes in lens characteristics with temperature. A. F. TURNER. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 654 (1940). A.P.

Clay-water relationship. H. H. MACEY. *Proc. Phys. Soc.* [London], **52**, 625–56 (1940).—If the plastic mixture of clay and water is subjected to a steady pressure between porous pistons, the applied pressure, P, is related to the equilibrium moisture content, M, by the expression $P = ae^{-\beta M}$, and the aqueous conductivity, C, obeys a similar relation: $C = \theta e^{\phi M}$ (a and β are experimental constants for each clay, while θ and ϕ are experimental constants for each batch of clay). The validity of the assumption that the water movement during drying is associated with the pressure, P, and the extrapolation of the empirical formula for P and C to moisture contents below those possible experimentally is demonstrated by a comparison of experimental and calculated moisture-content distributions in clay bars drying from one end only. The variation in C cannot be explained if the viscosity of the water in the mixture is the same as that in the bulk, but the experimental data on a wide range of clays are in agreement with the supposition of an anomalous viscosity which is very large at the solid-liquid interface and decreases exponentially with distance from that interface. This is attributed to an intensity of crystal structure in the water which decreases from the interface in a similar manner. The apparatus used in determining the pressure, the moisture content relation, and the aqueous conductivity and a drier used for determining the moisture-content distribution are shown. 40 diagrams. L.E.T.

Conversion tables for hardness tests. ANON. *Canadian Machinery's Data Sheet*, No. 11; *Can. Machinery*, **50** [11] 37 (1939).—The Rockwell, Brinell, Vickers, and Firth diamond hardness numbers are given. D.A.B.

Extreme case of the performance of the eye versus that of the spectrophotometer. I. H. GODLOVE. Presented at the 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 656 (1940). A.P.

Fields of application for compressed-air molding machines. W. CASPARY. *Giesserei*, **27** [23] 446–50 (1940).—C. discusses the importance of selecting the correct type of molding machines for the successful operation of a foundry. Modern molding machines operated with compressed air are described. This type of machine is advantageous and economical, especially for quantity production of smaller parts. Illustrated. M.H.

Finished ware conveying system sustains production at Carr-Lowrey. ANON. *Glass Ind.*, **21** [10] 437–40 (1940).—Ware-handling needs occasioned by installation of a new production unit have been met by a comprehensive conveying system from lehrs to warehouse and shipping department. 9 photographs. A.P.

Improved potentiometric recorder-controller. GEORGE KENT. *Jour. Sci. Instruments*, **17** [11] 266 (1940).—Improvements on the Mark II potentiometer include a bold indicating scale and an increased area of chart. Improvements have been made in chart-loading and general accessibility. 1 photograph. J.L.G.

Improved radiation pyrometer. T. R. HARRISON AND W. H. WANAMAKER. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 655 (1940). A.P.

Infrared in industry. JOHN SASSO. *Amer. Machinist*, **84** [22] 867–69 (1940); see *Ceram. Abs.*, **19** [10] 239 (1939). M.H.

Measurement of numerical aperture. R. BRUCE HORSFALL, JR. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 655 (1940). A.P.

Mount for the universal stage study of fragile materials. R. J. DIMLER AND M. A. STAHLMANN. *Amer. Mineralogist*, **25**, 502–504 (1940).—To avoid the crushing of fragile materials a brass plate, 0.5 mm. thick, has a hole in the center just large enough for a cover glass. The grain is in oil between two cover glasses, and these are in the hole in the brass plate. The metal slide supports the weight of the hemisphere. The grain should be just large enough to be slightly pinched and thus held firmly. W.D.F.

Noticeability of color difference in daylight. D. L. MACADAM. Presented at 25th Annual Meeting, Optical Society of America, Oc ., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 657 (1940). A.P.

Ophthalmic lens testing instrument. A. AMES, JR., AND K. N. OGLE. Presented at 25th Annual Meeting, Optical

Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 652 (1940). A.P.

Optical pyrometry. W. E. FORSYTHE. *Jour. Applied Physics*, **11**, 408–20 (1940).—Temperature determinations made from surface brightnesses are discussed in detail. A.P.

Polarimeter using sheet polarizing elements. R. S. ESTEY. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 658 (1940). A.P.

Potentiometer type optical pyrometer. LEEDS & NORTHRUP CO. *Jour. Sci. Instruments*, **17** [11] 265 (1940).—The special feature of this disappearing-filament optical pyrometer is a potentiometer circuit (*Ceram. Abs.*, **19** [9] 220 (1940)) which eliminates several of the usual elements of such a circuit. The instrument and its operation are described in detail. Two ranges are provided, 775° to 1225°C. and 1075° to 1750°C. A third range of 1500° to 2800°C. can be supplied at an additional cost. The price of the two-range instrument is $185. One photograph. J.L.G.

Regulation of tungsten and mercury lamps. H. STEWART. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 652 (1940). A.P.

Selecting the crusher. STANLEY D. MICHAELSON. *Eng. Mining Jour.*, **141** [12] 41–45 (1940).—For small plants a jaw crusher passing 80% of the feed is economical; the rest of the feed is hand sledged. Crushers run by one man must have a slightly larger capacity to do all the crushing in several hours. Gyratory crushers have more capacity per hour for the same opening. Extra hard material requires an extra heavy crusher. Sticky or clayey material should be washed, or a jaw crusher with small nip angle should be used. Sometimes the most economical crushing does not produce a suitable product, and other methods must be used, e.g., to avoid fines. Blake-type crushers have a large capacity but do not produce a uniform product. Dodge-type crushers have a small capacity but produce a product of uniform size; they are sectionalized in order to be easily moved to remote locations. Single toggle crushers produce a more uniform product than the Blake-type crushers and are well adapted to average-sized plants. The surfaces may be straight or nonchoking or may have vertical corrugations. It is not economically practical to crush to less than 1/4 in. The elimination of the finished-size product from the feed increases capacity and reduces the power required. Graphs predicting the size analysis of a crusher product are given, and a table shows power, operating labor, and equipment for plants of various capacities crushing to different sizes. W.D.F.

Study of the rock drill. TOMIZI SUZUKI. *Amer. Doc. Inst. Doc.*, No. 1179; *Amer. Inst. Mining Met. Engrs. Contrib.*, No. 111; abstracted in *Trans. Amer. Inst. Mining Met. Engrs.*, **141**, 206–10 (1940).—A total of 25,000 tests made on 67 different rock drills involved air consumption, speed of rotation, torque of rotation, foot-pounds of striking energy, air pressure, input horsepower, and speed of rock penetration. S. expresses his views on the interrelation of these and derives formulas in support from the mechanics of impact. W.D.F.

Specially hard alloy cast iron for resistance to abrasion. M. M. HALLETT AND A. B. EVEREST. *Proc. Inst. Brit. Foundrymen*, **32**, 115–24 (1938–39).—Martensitic white cast iron known as Ni-Hard was obtained by substituting the hard constituent, martensite, for the comparatively soft pearlite in cast iron. This change was affected by the rates of cooling, the composition, and the heat treatment. The relation between composition, size of section, and hardness is shown in Table I. Some typical compositions of Ni-Hard sand castings are given in Table II. In all cases the manganese content should be between 0.3 and 0.5, the sulfur content about 0.1%, and the phosphorus content 0.4% maximum. Molybdenum may also be present if desired. In Table II, composition A is recommended for sandblast nozzles, composition C or F for grinding-mill balls, and composition E for grinding-pan bottom and grinding plates. R.H.

TABLE I

Reference mark	Percentage composition: Total C	Si	Ni	Cr	Vickers diamond hardness values, Size of section (in.): 1/8	1	2
A	3.20 to 3.23	0.55 to 0.61	2.21	0.97 to 1.01	724	576	581
B			2.47		707	650	595
C			2.68		689	710	640
D			2.96		707	627	740
E			3.33				772
F	3.23 to 3.34	0.48 to 0.53	1.10	1.80 to 1.85	650	599	560
G			1.76		720	650	596
H			2.24		681	715	627
I			2.51		686	759	662
J			2.75		693	743	765
K			2.93		653	746	759
L			3.09		627	760	792
M			3.29		654	743	772
N			3.46		640	743	762
O			3.79		681	733	727
P			4.27		650	678	697
Q			4.51		627	710	700
R	2.81 to 2.84	0.40 to 0.45	2.34	1.47 to 1.50	733	670	558
S			2.49		762	750	616
T			2.83		654	762	762
U			3.05			724	
V	3.30	0.55	Nil	4.91	620	585	560

TABLE II

Reference mark	Section (in.)	Properties required	Percentage composition: Total C	Si	Ni	Cr
A	1/4 to 1/2	Maximum hardness	3–3.6	0.8	2.5	1.5
B	1/2 to 2			0.6	3.2	1.7
C	2 to 4			0.5	4.5	2.0
D	1/4 to 1/2	Maximum toughness	2.7–3.2	0.5	3.0	1.5
E	1/2 to 2				4.0	1.7
F	2 to 4				5.0	2.0

Supersonic cell fluorometer. H. B. BRIGGS. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 653 (1940). A.P.

Technical investigations and calculations on the heat used in drying in the tile industry. HEINZ ROTH. *Ber. Deut. Keram. Ges.*, **20** [10] 427–47; [11] 457–76 (1939).—Three installations for drying in the tile industry were investigated. In the first, the hot air passes through the drying chambers and then out to the open air. In the second, the hot air is first brought to the partly dried tile and finishes drying them; after the air has absorbed moisture it is brought to the unheated tile. The third installation is a tunnel drier operating on the counter-stream principle, i.e., the hot air is admitted at the end of the tunnel where the dried ware emerges. The changes in moisture content and the efficiencies were determined. The efficiency in the use of air is the ratio of the water content of the waste air to the water content of the air when saturated at a corresponding pressure. Changes in the condition of the ware to be dried and of the air in the course of the drying were also calculated. The results of measurement and calculation check well. The following table shows the efficiencies obtained.

Drying system	Use of heat: Actual (cal./kgm.)	Theoretical (cal./kgm.)	Efficiency in use of heat (%)	Efficiency in use of air (%)
Single use of air	3150	670	21.0	78.0
Chambers separately heated	1500	720	48.0	97.8
Tunnel drier	1100	680	62.0	93.5

With a specific use of heat of 1100 Cal. per kgm. and a heat utilization of 62%, the tunnel drier surpasses the separately heated chambers with a use of heat of 1500 Cal. per kgm. and only 48% utilization of heat. In comparing these two independently heated drying installations with the first method (with heating by the kiln) it must be remembered that the efficiency of the latter is calculated by using only the hot air brought by the blower. The drying effect of the outside air (always a factor in drying over kilns) cannot be determined and therefore is not taken into consideration. The only partial utilization of the dry air in this installation shows the superiority of the two independently heated installations in regard to heat economy. The question of drying costs in the different drying systems is not dealt with because of the many different cases which occur in the tile industry. The question of economy requires a special study for each operation. The efficiency of the drying system used is determined by many factors such as the kind of manufacture (in regard to form, weight, and size of the product), the characteristics of the clay used, the wetness of the material to be dried, the volume and regularity of production, and the cost of electricity and other necessary energy (such as steam and waste heat). W.H.H.

Temperature radiation emissivities and emittances. A. G. WORTHING. *Jour. Applied Physics*, **11**, 421–37 (1940).—The definitions, methods, and results of emissivity and emittance measurements are considered. A.P.

Thermoelectric thermometry. W. F. ROESER. *Jour. Applied Physics*, **11**, 388–407 (1940).—R. discusses the fundamental laws and theories of thermoelectric phenomena and their historical development as well as the application of these phenomena to the measurement of temperature. Thermoelectric thermometry, with particular regard to the types of thermocouples, the protection of thermocouples, and the fundamental considerations in temperature measurements are treated primarily from the practical standpoint. A.P.

Temperature and temperature scales. H. T. WENSEL. *Jour. Applied Physics*, **11**, 373–88 (1940).—W. discusses the fundamental concepts involved in the general subject of temperature and develops methods of expressing it. The basis and significance of a thermodynamic scale are discussed, and the relation of various practical scales to the thermodynamic scale is explained. A.P.

Viewing angle of reflectometry. E. Q. ADAMS. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 656 (1940). A.P.

SEPARATE PUBLICATION

Quantitative Spectrographic Analysis with the Microphotometer: I, Review of Published Work. D. M. SMITH. *Brit. Non-Ferrous Metals Research Assn., Research Rept. R.R.A.*, No. 524, 24 pp. (1939). Price 2s. Reviewed in *Metal Ind.* [London], **56** [15] 335 (1940).—The introduction of the microphotometer, which provides a means of determining the relative blackenings of the lines used in the analysis, has improved the precision of the method and greatly increased its industrial application. 54 references. H.E.S.

PATENTS

Clay-molding machines. D. G. BERRY. Brit. 529,642, Dec. 18, 1940 (May 22, 1939).

Device for the shredding of material in a wire cutting press. EMANUEL DÜRST AND OSKAR DÜRST. Ger. 656,024, Jan. 13, 1938 (Dec. 16, 1933); VI/80*a*. 26.—Cutting wires, thin knife blades, etc., are tightened between two rings behind the particle plate in the deairing chamber and run oblique to the wire. **Ger. 683,617,** Oct. 19, 1939 (Dec. 23, 1937); VI/80*a*. 26; addition to Ger. 656,024.—The clay charge is shredded oblique to the pressing direction in the deairing chamber by cutting wires, knives, bands, etc., which form the spokes of a wheel. Several of these wheels may be used, working separately or in conjunction. D.A.B.

Means for transferring bottles, etc., from one conveyer to another. BARNETT & FOSTER, LTD., AND C. W. RAYMOND. Brit. 530,748, Jan. 1, 1941 (July 1, 1939).

Meter for granular or powdered materials. JAMES EDWARD LEA. Can. 393,300, Dec. 24, 1940 (Jan. 11, 1939). G.M.H.

Pulverizing device for deairing wire cutting presses, clay cutters, etc. EMANUEL DÜRST, AND OSKAR DÜRST. Ger. 680,543, Aug. 10, 1939 (Nov. 30, 1936); VI/80*a*. 26.—Rods having a cog-like structure are employed whose cutting edges are inclined to the direction in which the pressed mass passes. D.A.B.

Removing magnetic impurities from finely divided materials. G. J. BAIR AND J. S. CORT, JR. (N. S. Garbisch). U. S. 2,230,344, Feb. 4, 1941 (Oct. 22, 1938).

Re-press brickmaking machines. T. C. FAWCETT, LTD., AND D. L. FAWCETT. Brit. 530,662, Jan. 1, 1941 (June 29, 1939).

Support for holding roofing tile and similar drying objects. OLA OSTDEUTSCHE LANDWERKSSTÄTTEN G.M. B.H. Ger. 685,602, Nov. 30, 1939 (Feb. 29, 1936); V/82*a*. 26.—The framework and its carrying supports are fastened onto the ceiling of the drying chamber. D.A.B.

Kilns, Furnaces, Fuels, and Combustion

Burning of carbon during the firing of porcelain bodies. N. P. ZGORMIK. *Keram. Sbornik*, **1939**, No. 1, pp. 43–48.—Carbon burns out effectively in oxidizing atmosphere beginning at about 600°. The intensity of the burning of carbon increases with increasing temperature and drops with increasing degree of vitrification of the body; thus this optimum temperature in a ceramic body depends upon the properties of the mix (composition, grinding fineness, etc.). The carbon which penetrates into a thin-walled porcelain body during firing may be completely eliminated by a 4 hr. firing in an oxidizing atmosphere at 900°. For thick-walled porcelain, an 8 hr. firing in an oxidizing atmosphere at 900° to 1000° is sufficient. M.V.C.

Ceramic kilns heated by producer gas, furnace gas, and electricity. Characteristics and comparisons. A. RITTGEN. *Ber. Deut. Keram. Ges.*, **20** [8] 373–87 (1939).—Producer gas is generally used. If the gas has to be delivered a considerable distance, the tar should be removed immediately after leaving the producer. Furnace gas is obtained from blast furnaces and coke ovens and is delivered through pipe lines for great distances. The absence of tar in this gas permits the section of the gas pipes to be reduced. Producer gas and furnace gas differ in regard to products of combustion as well as in original chemical composition. The furnace gas has a theoretically higher burning temperature (2100°C.) than producer gas (1700° C.) because of its higher heating value. In burning furnace gas the products of combustion are 2.5 to 3 times the volume of those from producer gas. Producer gas has a lower sulfur content than unpurified furnace gas, but the hydrogen sulfide can be removed from furnace gas. In general, furnace gas is more advantageous than producer gas because of the large amount of space required by the gas producers. In case of war, however, producer gas is more advantageous because the pipe lines required for furnace gas may be easily damaged. The newest form of energy in the ceramic industry is electricity. The electrically heated ceramic kilns are preferred because of the ideal possibilities of distribution and regulation. It is easily possible to keep the temperature constant to ±5° even with the largest kilns yet built. Even if electric firing in ceramics has been limited to oxidizing firing, reducing firing is no longer a problem, although this is most simply accomplished with solid fuels. It is difficult to determine what method of heating is correct except for specific cases when all factors of cost are considered. Comparative costs of the use of producer gas, purified gas, and electricity for heating are given in tables. In each

case electricity was the most economical, the cost with electric heating varying from 0.01 to 0.0025 Rm. per kw.-hr., depending upon the required temperature and other conditions. R. attempts to explain briefly the three principal types of energy used for heating ceramic kilns. Every kind of energy has its justification in the right place. W.H.H.

Continuous kilns. S. ROUND. *Claycraft*, **13** [8] 239 (1940).—A saving of 35 cwts. of coal per thousand brick fired is effected by using continuous kilns instead of the intermittent kiln. The chief features are continuous action and the method of firing (grate fire, top fire, or producer gas fire). G.A.K.

Future development of the tunnel kiln in the fine ceramic industry. NICOLA LENGERSDORFF. *Ber. Deut. Keram. Ges.*, **20** [10] 448–52 (1939).—In a previous paper (*Ceram. Abs.*, **18** [10] 277 (1939)), F. Dettmer inadequately discussed the Lengersdorff tunnel kiln. Dettmer was works manager of a tunnel kiln in England, with Lengersdorff's approval, and there learned all the necessary features of operating such kilns. He introduced valves in the gas pipes which regulated the amount of gas to each burner. He can make no claim to novelty with regard to the use of purified gas and hot air under regulated constant pressure and to the corresponding division of the kiln into independent zones as these were used in the Lengersdorff tunnel kiln of 1927 to 1928. See "Tunnel . . .," *ibid.*, **19** [10] 242 (1940). W.H.H.

Measurement of temperature and flow in furnace systems. A. H. LECKIE. *Fuel*, **19**, 20–23 (Jan.–Feb., 1940); *Jour. Iron & Steel Inst.*, **141** [1] 287A (1940).—In the course of work for the Open-Hearth Committee of the Iron and Steel Industrial Research Council, L. developed a suction pyrometer and a water-cooled Pitot tube which enabled him to measure gas temperatures and velocities in furnace passages where temperatures of 1550 °C. are attained. The results of temperature and flow measurements in the open-hearth furnace are given. The results indicate that, although waste-gas temperatures in the flues below the checkers may be estimated without serious error by an exposed thermocouple, such a thermocouple will give an entirely erroneous impression of the temperature of the ingoing air.

Method of stoking kilns. ANON. *Arts du Feu*, **2**, 156 (1939); *Trans. Brit. Ceram. Soc.*, **39** [3] 23A (1940).—The Stein and Roubaix automatic stoker is described and illustrated. See "Pot . . .," *Ceram. Abs.*, **19** [1] 13 (1940).

Radiant heat transfer in ceramic kilns. F. B. HODGDON. *Iowa State Coll. Jour. Sci.*, **14**, 48–49 (1939); *Brit. Chem. & Phys. Abs.–B*, **59** [6] 444 (1940).—Since, at high temperature, heat radiated by H_2O vapor and by CO_2 accounts for more than 90% of the total heat transferred from the products of combustion to the products in the kilns, experiments were made to determine if ceramic firing could be improved by adding these gases without deleterious effects. Investigations on hollow tile fired in a muffle at constant temperature showed that the porosity on firing in H_2O vapor was less than that on firing in CO_2 which was less than that on firing in air. Explanations are discussed.

Tunnel kilns. E. W. EDWARDS. *Claycraft*, **13** [8] 225–26 (1940).—E. gives three examples of tunnel kilns for firing refractories. Details of dimensions, fuel consumption, labor, and economies are presented. G.A.K.

Working continuous kilns. CHARLES HILL. *Claycraft*, **13** [4] 113–18 (1940).—H. discusses the operation of a continuous kiln under the following headings: (1) Draft: if the gases passing through the fan are below 100 °F., a torpid draft is created and the consumption of power by the fan is very high. The temperature of the gases should not be less than 173 °F. to insure an efficient draft. (2) Density of setting: to increase fire travel less brick should be set in each chamber. (3) Drying and driers: when goods are placed from the machine directly into the kiln, the hot air used to dry them should leave the cooling chambers at 300° to 400 °F. and should heat up the drying chambers to 140 °F. If a separate drier is used, the temperature of the air and gases entering the drier should be 240° to 320 °F. (4) Drying in the kiln: less damage is done to the brick by direct setting. When drying brick in a continuous kiln, all openings into the chamber should be fully open, and the hot air should be controlled by the main flue dampers. (5) Placing the goods: the density of the brick should be considered, as the denser the brick, the more difficult it is to dry and fire. (6) Pathways: zigzag kilns require close setting in the lower portion and wide spacing in the upper part. Archless kilns require close setting in the lower half and a special set of flues in the top part. (7) Fuel. (8) Cracks: causes and remedies are discussed. (9) Firing. (10) Causes of unburned fuel: (*a*) a damp sole in the kiln, (*b*) damp fuel, (*c*) too-rapid advance, (*d*) poor draft, (*e*) excessive fuel. (11) Black cores and burst brick. (12) Automatic stokers. A plan for a double hot-air flue and a plan of a combined kiln and drier are presented. G.A.K.

PATENTS

Liquid-cooled annexed head for heating elements for producing high temperatures as in electric furnaces. REINHOLD REICHMANN (Siemens-Schuckertwerke A.-G.). Ger. 687,591, Jan. 11, 1940 (Jan. 27, 1937); VIII*c*/21*h*. 15.01.—A heat conductor is surrounded by a gastight ceramic protecting tube. A cylindrical metal object soldered or fused with the protective tube ends renders the inside of the tube gastight and facilitates the conduction of current to the heating element ends and the conduction of heat from the element ends. This cylindrical metal object is loosely joined with a cooling head by means of a screw joint. D.A.B.

Means for supporting and placing pottery, etc., during firing processes. W. E. MADDOCK. Brit. 531,873, Jan. 22, 1941 (Aug. 5, 1939).

Resistors for electric furnaces. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Brit. 530,949, Jan. 8, 1941 (July 28, 1938).

Geology

Adsorption of malachite green by clays and allied minerals. V. L. BOSAZZA. *Nature*, **146** [3697] 334 (1940).—In every case where the sample was contaminated, the main impurity was quartz which, fortunately, does not take the dye.

Mineral	Color of stained mineral	Pleochroism
Kaolinite	Deep blue-green	Marked
Anauxite	Light to deep blue-green	Not very marked but variable
Montmorillonite	Marine blue	None
Pyrophyllite	Blue-green	"
Talc	Blue-green	"
Beidellite	Marine blue	"
Margarite	Not markedly stained	"

So far no accurate diagnostic values of the amount of adsorption for the various minerals have been found. J.L.G.

Age of the uraninite from the McLear pegmatite near Richville Station, St. Lawrence Co., N. Y. B. M. SHAUB. *Amer. Mineralogist*, **25**, 480–87 (1940).—Uraninite was obtained from the mine in pegmatite. It is 1094 million years old or of the Laurentian age. W.D.F.

Bleaching earth—natural and activated. F. NEURATH. *Chem. Age* [London], **43** [1121] 287–88 (1940).—Fuller's earth for bleaching oils, fats, and waxes was discovered in England and dominated all markets until about 1800 when bleaching earths of equivalent qualities were found in the United States. Later, other clays were used after being activated with sulfuric acid or hydrochloric acid. In 1907

the Pfirsching Mineral Works placed an activated Bavarian earth on the market under the trade name Frankonit. Shortly afterward, the Moosburg Clay Works introduced another activated Bavarian earth under the name of Tonsil. Several similar works were opened in Bavaria, and a large industry was founded. A.B.S.

Chemical composition of garnet associated with cordierite. ROBERT E. FOLINSBEE. *Amer. Mineralogist*, **26**, 50–53 (1941).—Garnet associated with biotite and cordierite averages about 75 almandite, 20 pyrope, and 5% other molecules, with only a little variation. This is because cordierite is not stable in a calcium-rich environment. W.D.F.

Cristobalite in bentonite. JOHN W. GRUNER. *Amer. Mineralogist*, **25**, 587–90 (1940).—X rays of bentonite from Gillette, Wyoming, compared with X rays of natural cristobalite and devitrified Pyrex brand glass, showed that the bentonite contained montmorillonite and cristobalite. Chemical analysis of the bentonite showed about 30% cristobalite. This cristobalite must have been formed in the throat of a volcano and blown out together with the ash which formed the bentonite. W.D.F.

Determination of soil structure by microscopical investigation. G. C. REDLICH. *Soil Sci.*, **50** [1] 3–12 (1940).—R. describes a method for visually observing the structure of a soil with the aid of the microscope. Methods for expressing pore space and those developed from Kubiena's thin-section technique are included. On the theory that the soil structure depends on the size of pore spaces as well as on the size of the particles of solid material, a ratio is proposed which takes into account the pore space and the larger aggregates. For this ratio, the term "soil quotient" is proposed. The quotient is believed to express the soil structure. G.R.S.

Experimental flow of rocks under conditions favoring recrystallization. DAVID GRIGGS. *Bull. Geol. Soc. Amer.*, **51** [7] 1001–1022 (1940).—To apply the results of experimental investigations of the flow of rocks with any degree of assurance to problems of rock deformation in nature, it is necessary to investigate the effects of all five of the varying environmental factors, viz., confining pressure, shear stress, temperature, time, and the presence of solutions. Reconnaissance experiments indicate the important role which solution and recrystallization may play in rock deformation. A.C.B.

Exsolution growth of zincite in manganosite and of manganosite in periclase. CLIFFORD FRONDEL. *Amer. Mineralogist*, **25**, 534–38 (1940).—At Franklin, N. J., manganosite occurs with plates of zincite on its parting surfaces and with zincite {0001} [10$\bar{1}$0] parallel to manganosite {111} [011]. Zn is only slightly soluble in MnO, but if present near a 111 MnO face the zincite plates move to the positions to be occupied by the Mn and crystallize there, with the orientations given. Periclase from Langban, Sweden, has manganosite intergrowths so that manganosite {111} [011] is parallel to periclase {111} [011]. These two are identical in structure and nearly the same size; thus manganosite can crystallize from periclase without regard to its own habit. W.D.F.

"Flow" in stressed solids: Interpretation. ROY W. GORANSON. *Bull. Geol. Soc. Amer.*, **51** [7] 1023–34 (1940).—G. gives an interpretation of the mechanism involved in the phenomenon variously called "creep," "plastic flow," and "pseudoviscous flow." From the mechanism proposed herein, various formulas are derived which satisfactorily correlate and fuse phenomena hitherto discussed as being somewhat unrelated in treatments on strength, stress, strain, and strain rate. According to G.'s hypothesis, plastic flow in solids takes place by means of a change-of-phase transfer mechanism such as solid → fluid → solid or solid → solution → recrystallization of solid. From consideration of the thermodynamic potential relations, expressions are derived for different physical conditions. The quantity that has been related to the viscosity of a fluid is thus seen to be a function of the "activation energy." If the hydrostatic confining pressure is high, release of the energy of deformation stored up in the crystal lattice can take place only by a change-of-phase mechanism. See "Physics . . . ," *Ceram. Abs.*, **19** [8] 202 (1940). A.C.B.

Fluorspar of Corvara. S. MORGANTE. *Periodico Mineral.* [Padua], **10**, 379–91 (1939); abstracted in *Chem. Zentr.*, **1940, I**, 3905.—Fluorspar is the principal mineral of the deposits in Val di Pennes, Bolzano (*ibid.*, **1939, II**, 1169). It has a granular structure and is an apple-green color. Colorless crystals, light-green crystals, and bright-green crystals were studied. The specific gravity of the light-green crystals is somewhat higher than that of the colorless and bright-green crystals. Luminescence from ultraviolet light rays or X rays and heat increases from the colorless to the bright-green crystals. The only impurities were 0.05% SiO_2 in the light-green crystals and 0.09% SiO_2 and 0.008% Fe in the bright-green crystals. Fe produces the coloring and SiO_2 produces the turbidity in the green varieties. M.V.C.

Geologist's sketch of Meigs County. WILBER STOUT. *Ohio State Univ. Eng. Expt. Sta. News*, **12** [5] 3–7 (1940).—The surface rocks from west to east are the Conemaugh and Monongahela series of the Pennsylvanian system and the Permian system. They are mainly shales and sandstones with subordinate limestones. Coal, salt, petroleum, and natural gas are the mineral products. W.D.F.

Hydrothermal formation of clay minerals in the laboratory: II. F. H. NORTON. *Amer. Mineralogist*, **26**, 1–17 (1941).—Using higher CO_2 pressure, N. found that reaction practically ceases at the highest pressures. Optimum conditions, per cent of conversion, and products are given for the minerals: (1) Albite, 30% converted to montmorillonite or beidellite at 300°C. and 250 lb. per sq. in. CO_2. (2) Nephelite, 100% converted to sericite and gibbsite at 300°C. and 500 lb. pressure. (3) Orthoclase, 80% converted to sericite at 300°C. and 650 lb. pressure. (4) Spodumene, 100% converted, over a large field, to kaolinite and dickite at 300°C. and 125 to 950 lb. pressure. (5) Anorthite, 70% converted to montmorillonite or beidellite at 300°C. and 500 lb. pressure. Other minerals, treated once at 300°C. and usually at 500 lb. per sq. in., gave the following end products: leucite—sericite; petalite (at 250 lb. pressure)—kaolinite; lepidolite—quartz; beryl, pollucite, and kaolinite, no change; analcite—kaolinite, quartz, and dickite; scolecite—sericite; and volcanic glass—sericite and dickite. Stronger acids substituted for the CO_2 sometimes showed less conversion. The end products are similar to the clay minerals named but are not identical in every respect. For Part I see *Ceram. Abs.*, **18** [4] 111 (1939). W.D.F.

Influence of microorganisms on soil aggregation and erosion. JAMES P. MARTIN AND SELMAN A. WAKSMAN. *Soil Sci.*, **50** [1] 29–47 (1940).—Two artificial soils, sand-bentonite and sand-clay mixtures, and two natural soils were used. The action of microorganisms resulted in a marked binding and aggregation of the soil particles, the extent of the binding depending on the organisms concerned and the nature of the organic material added. G.R.S.

Infrared absorption spectrum of several silicates. F. MATOSSI AND O. BRONDER. *Z. Physik*, **111**, 1–17 (1938).—The absorption spectra of seven silicates and one absorption spectrum of glass were investigated in the range 1 to 8.5μ (some to 15μ), and these spectra were explained by the method of frequency combinations. The authors confirm the assumption, already evolved from reflection measurement, that mainly only the oscillations of the (SiO_4) groups serve as an explanation of the difference between spectra. The frequency of pulsation, which according to previous work was believed to be about $^1/_{800}$ cm. (12.5μ), must be considered as part of the explanation. This frequency functions as the primary oscillatory movement of the (SiO_4) groups. The effect of the water content of silicates on the spectrum is discussed. In other words, it was previously determined that a frequency of pulsation of 800 $cm.^{-1}$ (12.5μ) existed as a primary frequency in the investigation of silicates. This is now found to be the primary frequency of vibration of the (SiO_4) group. The following silicates were examined: zircon ($ZrSiO_4$),

topaz ($Al_2(F,OH)_2SiO_4$), benitoite ($BaTiSi_3O_9$), beryl ($Be_3Al_2Si_6O_{18}$), muscovite ($KAl_3(OH)_2Si_3O_{10}$), biotite ($(K,Mg,Fe)_2Al_2(OH)_2Si_2O_{10}$) adular ($KAlSi_3O_8$), and one alkali glass. Graphs show the percentage of light passing through thin specimens of these minerals vs. the frequency of the light. See *Ceram. Abs.*, **18** [10] 267 (1939). J.P.S.

Laws of soil colloidal behavior: XXII, Thermal stability of acidoids and basoids. ANDERS HOVDEN, LAMBERT WIKLANDER, AND SANTE MATTSON. *Soil Sci.*, **50** [1] 65–76 (1940).—The thermal stability of soil acidoids and basoids seems to place them in the following order: free humus acidoids < sesquioxide-bound humus acidoids < sesquioxide basoids < silicic acidoids. As a result of the destruction of the humus acidoids by heating for 6 hr. to 275°C., the exchange reactions of the soil become an expression of the mineral acidoid/basoid activity ratio and serve to characterize the soil type. For Part **XXIA** see *Ceram. Abs.*, **19** [8] 198 (1940). G.R.S.

Lysimeter studies: IV, Movement of anions through the profile of a gray-brown podzolic soil. J. S. JOFFE. *Soil Sci.*, **50** [1] 57–63 (1940).—The results of tests on the movement of various anions from one horizon to another were as follows: for the A horizon, the per cents of anions leaving the A_1 and leaching through the A_2 were S 42, Cl 40, NO_3–N 34, SiO_2 32, and P 17; for the B horizon, the per cents of anions leaving the A_2 and leaching through the B_1 were SiO_3 59, Cl 33, P 27, S 17, and NO_3–N 14. G.R.S.

Mineral property valuation. GUY C. RIDDELL. *Eng. Mining Jour.*, **141** [11] 37–40 (1940).—Formulas to determine the value of the total future earnings are desired. The Hoskold formula provides for two rates, one low (on capital redemption funds) and one higher (on the capital investment). Several modifications have been proposed. The Grimes-Craigue formula has three rates, an intermediate one (on the sinking fund) being in addition to the other two. The Michigan system uses the Hoskold formula, each rate being 6%. The Hoskold formula is the soundest for mineral evaluation. See "Determining . . ." *Ceram. Abs.*, **20** [2] 55 (1941). W.D.F.

Minerals from southern California. JOSEPH MURDOCH AND ROBERT W. WEBB. *Amer. Mineralogist*, **25**, 549–55 (1940).—Fresh, measurable inyoite crystals were found at Mt. Blanco, Death Valley. Celestite and barite nodules were discovered in gypsiferous clay shales at Avawatz Mt., San Bernardino Co. Calcite nodules occur in bentonite at Mojave water camp, San Bernardino Co. Sand calcite crystals, with 64% sand, are in Red Rock Canyon, Kern Co. Others are veatchite, in seams in clay, Tick Canyon, Los Angeles Co.; rhodonite boulders in alluvial deposits, Cajon Pass, San Bernardino Co.; axinite, at both Erskine Creek, Kern Co., and Searles Lake quadrangle, Inyo Co.; and garnet and epidote in amygdules in lava boulders, Daggett, San Bernardino Co. Fayalite has been found in measurable crystals, with cristobalite and tridymite, in lithophysae in obsidian, Coso Hot Springs, Inyo Co. W.D.F.

Norwegian minerals of the beidellite group. T. F. W. BARTH. *Norsk. Geol. Tids.*, **19**, 300–310 (1940); abstracted in *Chem. Zentr.*, **1940, I**, 3764.—The minerals studied probably resulted from weathering before the glacial period. The weathered rock is criss-crossed with cracks containing a clayey substance. Beidellite has the approximate formula $Al_2O_3 \cdot 2SiO_2 \cdot nH_2O$. This mineral absorbs water. M.V.C.

Optical properties of tridymite. CORDELL DURRELL. *Amer. Mineralogist*, **25**, 501–502 (1940).—Large crystals of tridymite were found in Plumas Co., Calif. They were single pseudohexagonal crystals and were twinned as in aragonite or leucite. They were biaxial positive, 2V from universal stage methods 66° to 90° but mostly between 80° and 89°. Indices of refraction in sodium light are α = 1.478, β = 1.479, and γ = 1.481; all are ±0.001. The double refraction, determined independently, is 0.0025 ± 0.0002. W.D.F.

Petrography of two Iowa loess materials. F. LEICESTER CUTHBERT. *Amer. Mineralogist*, **25**, 519–27 (1940).—The two materials studied resembled each other by standard tests but behaved differently in a road subgrade. Chemical, X-ray, optical, and base-exchange studies were made on sized fractions. Sample A, down to one micron, showed mainly quartz and some muscovite; sample B showed quartz, muscovite, and limonite. The coarse colloid fraction for A is quartz, kaolinite, illite, and calcite; that for B is montmorillonite, quartz, and calcite. The fine colloid fraction for A is illite with a little kaolinite and quartz and for B, montmorillonite, illite, kaolinite, and quartz. The superfine colloid fraction for A is illite and montmorillonite and probably kaolinite; that for B is mainly montmorillonite with a little illite. B makes a better subgrade. W.D.F.

Physical properties of massive topaz. J. L. STUCKEY AND J. J. AMERO. *Jour. Amer. Ceram. Soc.*, **24** [3] 89–92 (1941).

Preparing and enriching clays with the aid of water (Hydroton). P. A. ZORIN AND S. M. ZHEREBIN. *Prom. Stroitel. Materialov*, **1940**, No. 1, pp. 73–74; abstracted in *Chem. Zentr.*, **1940, I**, 3695.—Clays which are mixed with large amounts of sand and other impurities can be cleaned and prepared for further working by washing in water; they are then left to settle. M.V.C.

Rapid-action soil tube jack. R. B. ALLYN. *Soil Sci.*, **50** [1] 49–51 (1940).—In obtaining samples with the soil tube, the extraction of the tube from the ground is often the most strenuous part of the operation. The device described was constructed to provide a simple, fast-acting jack, low in cost, for use in soil-moisture sampling. A diagram giving construction details is included. G.R.S.

Relation between chemical composition and refractive index in the biotites. A. JEAN HALL. *Amer. Mineralogist*, **26**, 34–41 (1941).—The relation between chemical composition and refractive index should be considered from the point of substitution of metal atoms in the structural formulas. The influence of Fe″, Fe‴, Ti⁗, and probably also Ti‴, Mn″, Zr⁗, Cr‴, etc., must be taken into account. A list of 59 biotites is given, and total iron as FeO is plotted against refractive index. Field 1 contains most of the iron-titanium biotites, and Field 2, at slightly higher indices, contains iron-titanium biotites with over 0.50% MnO. Biotites with little or no TiO_2 or with very high TiO_2 are outside of Field 1, with either lower or higher indices, respectively. By calculation, H. found that 1% TiO_2 raises the index 0.0046. In some cases this factor gives good results, but in others it is inaccurate, probably due to the influence of other substances. W.D.F.

Relation between color and chemical composition in the biotites. A. JEAN HALL. *Amer. Mineralogist*, **26**, 29–33 (1941).—H. presents a table of 56 biotites giving their color and partial chemical composition, total iron as FeO, TiO_2, and MgO. The biotites are plotted on a triangular diagram with FeO, TiO_2, and MgO at the vertices. Iron is responsible for the green color; titania gives brown and red. Magnesia dilutes the titania color. Although the composition might be used to determine the color, the color cannot be used to determine the composition as the fields are long and narrow. W.D.F.

Sorption by clays. T. N. JEWETT. *Soil Sci.*, **50** [3] 163–73 (1940).—McBain's term "sorption" is applied to the whole process of vapor uptake by soils and clays. Earlier work on the sorption of vapors is discussed, and the importance of the fundamental differences in the behavior toward water of montmorillonite and kaolinite clay types is stressed. The basis of this difference is considered to lie in the differences in the specific attraction for water of the minerals. Toluene sorptions of a number of clays were measured. The sorption of toluene is regarded as a particular instance of the sorption which takes place with any condensable vapor and which is a measure of such quantities as surface area and capillary distribution. The water sorptions of the same clays were measured. J. found that soil colloids with low silica contents sorb similar amounts of water and toluene, under the conditions of the experiments, but that those with high silica-sesquioxide ratios sorb much more water than toluene. See *Ceram. Abs.*, **11** [4] 281 (1932). G.R.S.

Stress in mine workings. PHILIP B. BUCKY. *Eng. Mining Jour.*, **141** [11] 33–36 (1940).—The models used are placed in a centrifuge to load them. Models of the same material are tested to failure; models of photoelastic materials are tested to determine pillar shapes and the best locations for the various parts of the mine. A certain pillar in a mine, when tested, showed that 60% of it could be cut out safely. W.D.F.

Structure and ore deposition at Cartersville, Georgia. THOMAS L. KESLER. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1226; *Mining Tech.*, **4** [5] 18 pp. (1940).—The Cartersville district is noted for producing chiefly brown iron ore, manganese oxide ore, barite, sienna, and magnesian limestone and for the minor production of clays, slate, gold, bauxite, and graphitic schist. The present ores are residual and oxidation products left from the weathering of the hydrothermal deposits. W.D.F.

Width of albite twinning lamellas. J. D. H. DONNAY. *Amer. Mineralogist*, **25**, 579–86 (1940).—The width depends on the obliquity of the twin. The smaller the obliquity of the twin, the higher is the frequency of the twin and the thinner are the lamellas. The curve obliquity against composition shows that the lamellas should be narrowest in oligoclase and should increase in width slowly toward anorthite and rapidly toward albite. For pure albite and anorthite, polysynthetic twinning is not expected. These predictions agree with the results of others. W.D.F.

Willemite morphology and paragenesis at Balmat, New York. FREDERICK H. POUGH. *Amer. Mineralogist*, **25**, 488–95 (1940).—Supergene willemite is found at the St. Joseph Lead Co. mine at Balmat. It is tabular and is embedded in chlorite. The willemite formation may have preceded the chlorite and is contemporaneous with and later than the chlorite. Some hematite and more willemite were then deposited; the willemite was etched and some sulfides were deposited. W.D.F.

BOOK

Geology of the Southern Alberta Plains. L. S. RUSSELL AND R. W. LANDES. *Geol. Survey, Bur. Geol. & Topography, Mines & Geol. Branch, Dept. Mines & Resources, Canada, Pub.*, No. 2453 (1940). 223 pp., 22 maps, 3 illustrations. Price, paper, 50¢.—Formations from the Cambrian to the Lower Cretaceous, inclusive, were discovered from boreholes. Upper Cretaceous and Tertiary formations outcrop at the surface. The most important of these are the Whitemud member of the Upper Cretaceous, which contains fire clays, and the Cypress Hills member of the Tertiary, which contains well-rounded quartzite pebbles suitable for use in grinding. These formations are discussed from the stratigraphic, structural, and paleontologic viewpoints only. G.M.H.

PATENT

Recovering lithium salts from lithium-containing minerals. K. A. SIVANDER AND S. J. WALLDEN (Bolidens Gruvaktiebolag). U. S. 2,230,167, Jan. 28, 1941 (Nov. 14, 1938).—A process for the recovery of lithium salts from silicate rocks containing lithium comprises extracting the rock with molten alkali metal sulfate selected from the class consisting of sodium and potassium sulfates in an atmosphere nonreducing to the sulfate at a temperature not substantially less than 850°C. and above the melting point of the sulfate, while maintaining the rock in the solid state, and separating molten sulfate containing lithium from the solid residue.

Chemistry and Physics

Alkali silicates. FOSTER D. SNELL. *Soap*, **16** [10] 28–31; [11] 35–37 (1940); *Chem. Abs.*, **35**, 283 (1941).—The manufacture, properties, and uses of silicates of 1:1 ratio and higher are discussed. Alkali silicates result from the fusion of silica with alkali carbonates or hydroxides. The ratio obtained depends on the ratio in the melt and on whether the carbonate or the hydroxide is used. Factors influencing the nature of the end product are time, temperature, and CO_2 pressure. There is no evidence that any compound more alkaline than the orthosilicate is to be expected, even if the silica is fused in a stream of inert gas.

Chromium ore: II, Determination of FeO in chromium ore. F. CAESAR AND K. KONOPICKY. *Ber. Deut. Keram. Ges.*, **20** [8] 362–66 (1939).—The FeO content of a chromium ore or of a chromium slag may be determined by solution in concentrated phosphoric acid (with the air excluded) in a gold or glass container and by subsequent titration with calcium permanganate. The duration of the test is 20 to 30 min. For Part III see this issue, p. 95. W.H.H.

Colorimetric determination of nickel as nickel-ammonia complex ion. GILBERT H. AYRES AND FRANCENE SMITH. *Ind. Eng. Chem., Anal. Ed.*, **11** [7] 365–67 (1939).—A method has been developed for the colorimetric estimation of nickel as its ammonia complex. The color of the complex is stable and is influenced very little by the addition of ammonium salt. The method has been applied to the analysis of nickel in a steel by utilizing dimethylglyoxime to separate the nickel and then converting the precipitate to nickel-ammonia complex ions for colorimetric determination. Illustrated. F.G.H.

Dependence of the viscosity-temperature relationship of acid blast-furnace slags on the chemical composition. KURD ENDELL AND RUDOLF KLEY. *Stahl & Eisen*, **59** [23] 677–85 (1939).—The viscosity measurements of seven acid blast-furnace slags whose ratio of $CaO:SiO_2$ varied from 0.39 to 0.86 gave viscosities ranging from 83 to 11 poises at 1400°C. (a viscosity of 25 poises corresponds to a fairly good flow from the blast furnace). With rising temperatures, all of the slags became less viscous. The proportions of certain metallic oxides were raised in the quaternary system SiO_2–Al_2O_3–CaO–MgO where the $CaO:SiO_2$ ratio was 0.91 to 0.68. In both cases, at temperatures between 1300° and 1500°C., these synthetic slags become thinner (more watery) with slight additions of oxides such as K_2O, Na_2O, and MgO. With an addition of 8% of these oxides, MgO makes the slag more watery than CaO. The same slag becomes viscous with slight additions of silicic acid and even more viscous with the addition of clay. The greater the ratio CaO + MgO + FeO + MnO + alkalis/SiO_2 + Al_2O_3 in wt. % (ratio ranging from 0.5 to 0.9), the smaller is the viscosity at any particular temperature between 1300° and 1500°C. 21 diagrams. See "Influence. . . ," *Ceram. Abs.*, **19** [8] 201 (1940). J.P.S.

Determination of silicon in fluorides. T. NAKAMURA. *Jour. Soc. Chem. Ind. Japan*, **43** [1] 50–51 (1940); Supp. Binding, pp. 33–34B.—N. made quantitative analytical experiments to determine silicon which coexists with large amounts of fluoride and small amounts of aluminum. The determination was made by titrating K_2SiF_6 with modifications; methyl red was used as the indicator. Silicic acid is converted to fluosilicate by alkali carbonate fusion or by treatment with hydrofluoric acid. In the latter method, it is necessary to remove the fluosilicic acid from the reagent. This method is more simple and more exact. M.T.

Geometrical crystallography of PbO_2 and Pb_3O_4. H. R. DAVIDSON. *Amer. Mineralogist*, **26**, 18–24 (1941).—Large crystals were prepared by heating PbO_2, NaOH, and water in a bomb. The PbO_2 is tetragonal, $c = 0.6785$. The Pb_3O_4 is also tetragonal, $c = 0.989$. W.D.F.

Magnetic susceptibilities of metallic oxides, especially those of chromium and manganese. S. S. BHATNAGAR, A. CAMERON, E. H. HARBARD, P. L. KAPUR, A. KING, AND BRAM PRAKASH. *Jour. Chem. Soc.* [London], **1939**, pp. 1433–41.—The application of Weiss's modification of the Curie law to the oxides of chromium and manganese gives values for the magnetic moment in accord with theory and enables magnetic measurements to be used for the evalua-

tion of the correct formulas of the oxides. The use of magnetic measurements is recommended as a means of following surface chemical processes on oxides. See *Ceram. Abs.*, **18** [10] 267 (1939). G.M.H. + R.A.G.

Optical properties of evaporated and of burnished vitreous quartz in the extreme ultraviolet. R. TOUSEY. Presented at 25th Annual Meeting, Optical Society of America, Oct., 1940; abstracted in *Jour. Optical Soc. Amer.*, **30**, 655 (1940). A.P.

Phosphorescence of zinc silicate phosphors. G. R. FONDA. *Jour. Applied Physics*, **10**, 408–20 (1939). A.P.

Polyborates. A. FERRARI. *Atti X° congr. intern. chim.*, **1938, II**, 634–38; *Jour. Soc. Glass Tech.*, **24** [105] 254A (1940).—K, Rb, Cs, and NH_4 borates can all be represented by the general formula $M_2B_{2n}O_{3n+1}$, $(n + 2)H_2O$. If it is assumed that the cation contains 1 mol. of water of crystallization, the modified formula $(M(H_2O))_2B_{2n}O_{3n+1}$, nH_2O corresponds with that of the tellurium borates previously described. The lesser tendency of Tl to become hydrated is probably due to the large number of extranuclear electrons, which screen the attraction between the positive nucleus and the O of H_2O. The composition of the hydrated NH_4 borates agrees with the suggested structures of the boric acids.

Reaction between magnesium oxide and titanium oxide in the solid state: III, Mechanism of the reaction. YASUO TANAKA. *Jour. Chem. Soc. Japan*, **60**, 949–57 (1939); *Chem. Abs.*, **34**, 1577 (1940).—The reactions between MgO and TiO_2 at 780°, 900°, 1000°, and 1200°, the diffusion of Mg and Ti ions in the solid phase, and the formation of crystalline $MgO{\cdot}TiO_2$ are discussed. See "Solid. . . ," *Ceram. Abs.*, **18** [7] 195 (1939); "Influence. . ," *ibid.*, **20** [1] 18 (1941).

Spectrochemical analysis. A. E. RUEHLE. *Sci. Monthly*, **50** [1] 41–44 (1940); see *Ceram. Abs.*, **19** [7] 176 (1940). H.E.S.

BOOK AND SEPARATE PUBLICATION

Experiments in Colloid Chemistry. ERNST A. HAUSER AND J. EDWARD LYNN. McGraw-Hill Book Co., Inc., New York, 1940. 178 pp., 70 figures, 13 tables. Price $2.00.—This book is divided into several chapters whose headings and sequence conform with those most generally found in modern textbooks or introductory treatises on colloid chemistry. The experiments described are preceded by brief introductions to give the reader an opportunity to acquaint himself with at least the fundamentals of the specific phenomenon so that the book, if read without the experimental procedures, consists of a brief synopsis of fundamental colloidal phenomena. Those interested in obtaining more detailed information are referred to the corresponding passages in recent pertinent textbooks or publications.

The experiments have been selected as a result of the experience of the authors during the past five years in various classroom demonstrations and laboratory courses offered by the Department of Chemical Engineering at the Massachusetts Institute of Technology. All the listed experiments have been carefully checked as to their workability. A bibliography and a subject index are included.

Numerical Solution of Laplace's and Poisson's Equations. GEORGE B. SHORTLEY, ROYAL WELLER, AND BERNARD FRIED. *Ohio State Univ. Eng. Expt. Sta. Bull.*, No. 107, 51 pp. (1940).—Laplace's equation is used to calculate the stress within photoelastic models, and Poisson's equation is used for torsional problems. W.D.F.

PATENTS

Colored titanium pigment. H. H. SCHAUMANN AND R. K. WHITTEN (E. I. du Pont de Nemours & Co.). U. S. 2,231,456, Feb. 11, 1941 (Dec. 6, 1938). H. H. SCHAUMANN, R. K. WHITTEN, AND R. W. BALL (E. I. du Pont de Nemours & Co.). U. S. 2,231,455, Feb. 11, 1941 (Dec. 6, 1938).

Making alkali subsilicates. C. W. BURKHART AND W. S. RIGGS (Pennsylvania Salt Mfg. Co.). U. S. 21,703, Feb. 4, 1941 (Aug. 10, 1940); reissue of original U. S. 2,083,545 ("Process . . .," *Ceram. Abs.*, **16** [8] 261 (1937)). W. S. RIGGS AND C. W. BURKHART (Pennsylvania Salt Mfg. Co.). U. S. 2,230,909, Feb. 4, 1941 (Sept. 17, 1936).

Producing magnesium hydroxide. KALI-FORSCHUNGS-ANSTALT G.M.B.H. Ger. 687,785, Jan. 11, 1940 (April 9, 1935); IV*b*/12*m*. 3.—$Mg(OH)_2$ is produced from magnesium salt solutions by means of sintered lime or dolomite. The sintered and pulverized precipitating agent in the unhydrolyzed state in a particle size of 0.2 to 2 mm. is added directly or after washing with relatively large amounts of water immediately before the addition. D.A.B.

Recovering lithium from minerals. BOLIDENS GRUVAKTIEBOLAG. Brit. 530,028, Dec. 18, 1940 (June 22, 1938).

Separating vanadium from titanium. L. G. JENNESS AND R. L. ANNIS (Vanadium Corp. of America). U. S. 2,230,538, Feb. 4, 1941 (March 20, 1940).—The process of removing vanadium from titanium compounds comprises adding to titanium tetrachloride containing vanadium an organic compound which will polymerize in the titanium tetrachloride in the presence of vanadium to form a polymer separable from the titanium tetrachloride and containing the vanadium, causing the compound to form the polymer containing the vanadium, and separating the polymer containing the vanadium from the titanium tetrachloride.

General

Action of talc dust on the lungs (experimental study). A. POLICARD. *Arch. Malad. Profess.*, **2** [5] 530–39 (1939–1940).—In 1896 Thorel (an anatomic pathologist of Nuremberg) found steatite dust in the lungs of a tuberculous worker, accompanied by pneumoconiotic and anthracotic symptoms. P. reviews experimental studies on the effect of talc dust on the tissues, beginning with Haynes (1931), who ascertained no permanent lesions in the lungs of guinea pigs after dusting them with talc. P.'s own experimental studies cover the effects upon white rats of the foliaceous industrial talc dust used in powdering rubber. These studies show that talc dusts, like asbestos dust, are particularly irritating to the upper respiratory passages and they produce intense dyspnea in animals. P. could not determine whether or not the increased mortality observed from the beginning of the dusting, with lesions then observable (bronchial dilation, acute emphysema, exudative alveolitis), is due to these phenomena of suffocation, as the mechanism of the phenomena remains inexact or obscure. The relatively short duration of these experiments does not permit any conclusion concerning the possibility of the development of fibrosis in a pulmonary tissue from the action of talc dust. 15 references. K.R.

Edward Bausch. EVERETT W. MELSON. *Bull. Amer. Ceram. Soc.*, **20** [2] 57–59 (1941).

Bausch and Lomb provide for the common defense. EVERETT WHITE MELSON. *Bull. Amer. Ceram. Soc.*, **20** [2] 59–61 (1941).—3 photographs. See *Ceram. Abs.*, **20** [3] 64 (1941).

Bausches give new site and buildings to Rochester Museum. ANON. *Bull. Amer. Ceram. Soc.*, **20** [2] 61–62 (1941).—1 photograph.

Ceramic engineering education. ARTHUR S. WATTS. *Ohio State Univ. Eng. Expt. Sta. News*, **10** [2] 10–11 (1938). W.D.F.

Chemical properties of siliceous industrial dusts. H. V. A. BRISCOE. *Jour. Roy. Soc. Arts*, **88** [4543] 104–19 (1939).—Since substances other than free silica, e.g., asbestos, or silicates present in anthracite coal dusts may produce disabling changes in the lungs, B. objects to

calling all such affections of the lungs "silicosis" and has nowhere found clear proof that the real causative agent of silicosis is silica. It appears more probable that both free silica and certain silicates have some common constituent or property which is the real cause of injury to the lung. Six years ago a study was begun of the chemical properties of siliceous dusts, both those thought "safe" as well as "dangerous." No method then in use was suitable for collecting unaltered samples of dust solids for examination. Mineral dusts were thought to be chemically nonreactive (inert). B. and his colleagues undertook to devise and perfect methods of sampling, which involved wetting with water or calcination at high temperatures, to supply "dust as the worker breathes it." Tests on samples obtained by the new methods showed at once that mineral dusts were extremely reactive, especially toward water, after contact with which they underwent extensive chemical change. Difficulties in securing the samples are reviewed; in many dangerous atmospheres, e.g., those associated with flint crushing, pottery making, metal mining, and asbestos manufacture, only 1 to 5 mgm. of dust per cu. m. were found, while very dense dust clouds at the working face of a coal mine exhibited 200 mgm. of dust per cu. m. At least 50 mgm. of dust are needed for complete examination, the solid particles, usually only $^1/_{1000}$ mm., being collected with 100% efficiency. Full descriptive and operative details of various kinds of filters are given, accompanied by illustrations, charts, and tables. The fine mineral dusts have interesting solubility properties. Dust particles floating in moist air become hydrated; considerable fractions of the silica and alkalis present become freely soluble in water. Calcined flint (almost pure silica) exhibits the same property and, as an air-borne dust, becomes hydrated up to 8 to 10%. As a result of comparative studies of the solubilities of various mineral dusts in water and in body fluids, B. concluded that determination of solubility in water warranted the assumption of solubility in body fluids. Water changes the original mineral of dusts into other minerals of less solubility; thus little value is attached to residual minerals in the lung, as what is found there after 20 years or more may have little relation to the mineral species which entered the patient's lung and eventually caused his death. Ordinary industrial dust usually contains a number of mineral species; these reduce the solubility of silica. **Criticism.** S. G. BLACKTIN. *Ibid.*, [4546] 197–98 (Jan., 1940).—B. states that available physical methods of securing dust as the worker breathes it are much more successful than the chemical methods advocated by Briscoe. The Briscoe filter contacts would necessarily alter the chemical constitution of particles under study. Blacktin discusses the alterative possibilities of the filters upon dusts and shows that their simplicity is more apparent than real and that the labyrinth operations are lengthy, costly, and redundant, in comparison with the more effective physical methods available. The difficulties of adsorption and the surface reactions of dust particles as treated by Briscoe are by no means as susceptible to solution in the present state of physicochemical knowledge as the far less complex difficulties of the mechanical interrelation of particles. See *Ceram. Abs.*, **17** [9] 317 (1938); **18** [9] 259 (1939). K.R.

Critical examination of respiration, heart, and circulation of the silicotic for determination of compensation. E. GAUBATZ. *Deut. Med. Wochschr.*, **66**, 464–67 (1940).—Usually a combination of disturbances of diffusion and of mechanical hindrance of respiration is present in the silicotic lung. These two disorders react adversely on the circulation, especially on the right heart. To test the function, G. proposes the combination of the regulation test of Schelling with the ergometric-spirometric test. Two illustrative cases are described. F.S.M.

Determination of physical fitness. H. H. KESSLER. *Jour. Amer. Med. Assn.*, **115**, 1591–95 (Nov. 9, 1940).—K. believes that the importance of examinations, either physical or psychological, as a measure of capacity for work is greatly exaggerated. Many defects of a minor character and some of a major character have little or no effect on the worker's capacity to carry out the requirements of his trade. The popular conception of fitness divides persons into the following classes: (1) ideal or superior, (2) normal or average, and (3) substandard or inferior. K.'s study of 6565 workers, however, showed that only 7% were free from gross defects, 70% had minor defects, 16% had advanced minor defects, and 7% had major defects. Experience shows that substandard workers are as a whole no more prone to accident than the standard group and and that, as age advances, accident frequency diminishes. The ability of the body to adjust itself to meet the requirements of life is not sufficiently appreciated. Fallacies which impair the usefulness of the tests used to determine the worker's capacity are pointed out. The importance of illness, especially the chronic systemic dieases, in affecting production is stressed. The relatively small number of workers prone to sickness accounts for a large number of days lost due to illness. G. concludes that "in the determination of physical fitness by means of the physical examination, the physician should bear in mind that the average man can do the average job." F.S.M.

Dust control in large-scale ore-concentrating operations. ROBERT T. PRING. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1225; *Mining Tech.*, **4** [5] 9 pp. (1940). W.D.F.

Economical dust control with low resistance exhaust systems: I, Analysis of the problem. F. F. KRAVATH. *Heating & Ventilating*, **37**, 40–42 (Oct., 1940).—This is the first of a series of six papers on low resistance exhaust systems. The fundamental principles of dust and fume removal are discussed. Two of the simplest methods are considered. The first consists of a fan in the center of the workroom ceiling with air inlets near or through the floor. In the second method, natural ventilation through a hood covering the source of dust or fumes and a vertical pipe are used. Neither method is sufficient when concentrations of dust or vapors are much above safe limits, and, in most cases, pipe systems with mechanical air movement are necessary. The necessary air velocity depends upon the nature of the process and may vary from 50 to 1000 f.p.m. The two first maxims on economy are as follows: (1) on the basis of good dust control, keep the hood face velocity at its lowest safe figure, and (2) keep the hood opening as small as possible. K. discusses the question of whether all the dust is to be transported to a collection center or whether the coarser material is to be dropped out in a cyclone or gravity filter or in a chip trap built into the hood or near it. If the dust is all fine and light, it may all be conveyed at a pipe velocity never higher than 3000 f.p.m. The Dalla Valle formula for pipe velocity is presented. The toxicity of various gases, fumes, and dusts is given in a table. **II, Hood and branch connections and importance of efficient elbows.** *Ibid.*, pp. 27–29 (Nov., 1940).—K. discusses the phenomenon called *vena contracta*, a contraction in the cross-sectional area of the air column which makes it somewhat less than the cross-sectional area of the pipe. This occurs after the air has encountered any obstruction, such as entering a pipe from a hood or traversing an elbow. When a uniform pipe leaves a large hood abruptly, the resistance through the hood may be 65% of the velocity pressure. This resistance may be greatly reduced by use of a flange (bellmouth or converging cone). With either the bellmouth or the converging cone flange, there is an optimum shape that has been determined by the Bureau of Standards. In the case of elbows, the *vena contracta* can be largely eliminated by the proper curvature and by the insertion of splinters or guide vanes. Two additional axioms are given: (3) always use the most efficient connection between hood and branch pipe, and (4) always use the most efficient elbow possible. **III, Branch junctions and changes in pipe sizes.** *Ibid.*, pp. 40–41 (Dec., 1940).—When a branch air pipe joins a main line or the cross section is enlarged or reduced, abrupt changes must be avoided. A junction in which the taper in the main pipe is as low as 7° and the branch enters at a very low angle produces much less turbulence and resistance than the common method of a 45° junction and a blunt taper.

In reducing the pipe size, the Moss reducer with a curved shoulder is even more efficient than a 7° taper. Two additional economy maxims are offered: (5) design branch junctions for utmost efficiency, and (6) in increasing or decreasing the velocity of air flow, especially at the entrance or exit of filters, traps, or other cleaners, always make this energy change in the most efficient manner. F.S.M.

German Ceramic Society, 1929–1939. Second decade since the founding of the Society. R. RIEKE. *Ber. Deut. Keram. Ges.*, **20** [9] 401–25 (1939).—R. describes the activities of seven local sections and six committees on raw materials, testing, machinery, heat, refractories, and fine ceramics. The publication of the Society's journal is discussed. W.H.H.

Low velocity exhaust systems. THEODORE HATCH. *Heating & Ventilating*, **37**, 27–30 (Oct., 1940).—The high air velocity (3000 to 4000 f.p.m.) necessary in common dust exhaust systems has the disadvantages of high power consumption, unbalanced air flow, settling of dust in low-velocity regions, wear on pipes, and loss of material. H. describes a method employing low air velocity in which most of the dust is deposited in a collecting chamber. This principle is applied in two installations in the same plant with variations required by mechanical differences. In both cases the operations are grouped around a collecting chamber into which the exhaust hoods open, sloping downward at an angle of 45° or more so that the dust falls into the chamber by gravity. Vertical exhaust pipes run 20 ft. above the roof and are provided with special terminal fittings which prevent the entrance of rain and snow but allow the dust to escape in a nearly vertical direction. In the first system, where scraping, cutting, and other processes are involved, the minimum face velocity is 1200 f.p.m., requiring a static suction of only 0.27 in. In the second system, ventilating a group of 22 lathes, the minimum air velocity in the dust-generation zone is 150 f.p.m. or 200 to 300 f.p.m. at the hood opening, created by a static suction of only 0.01 in. The cuttings and coarse dust are not collected by the air but are mechanically guided into the hood and are removed continuously from the chamber by a mechanical conveyer; the finest dust is carried by the exhaust pipe into the outside air or is filtered if necessary. In both cases the dust is effectively removed at a cost much lower than that of the ordinary process. F.S.M.

1939 and the clay and allied industries. H. HALLIDAY. *Claycraft*, **13** [4] 121–23 (1940).—H. discusses the effect of the first year of the war on the heavy clay and refractories industries. G.A.K.

Plate-glass industry precautionary measures. ANON. *U. S. Dept. Labor, Labor Standards*, **3**, 67 (July-Aug., 1940).—In the plate-glass industry measures for making workplaces safer have improved production or cut production costs. To reduce the dust hazard in handling the mix (mostly silica sand) from which the glass is made, one firm mixed the materials mechanically and made them into small briquettes. The dust was practically eliminated, and better melting and a more uniform product were obtained. See "Briquetting. . .," *Ceram. Abs.*, **18** [8] 205 (1939). F.S.M.

Prevention of silicosis by metallic aluminum. JÖTTEN. *Aluminium*, **22** [11] 575–78, 578–79 (1940).—Experiments with rabbits for over a year did not confirm the view of other investigators that the addition of metallic Al in powder form to dusts (quartz, silicates) prevents silicosis; a retarding action only was observed. An addition of 25% or 50% of pure Al silicate to pure quartz reduces the silicogenous action considerably. J. points out that the use of metallic Al is of purely theoretical interest; practical application is excluded because of the explosion possibility. A survey is made of the work done in this field. 15 references. See *Ceram. Abs.*, **18** [10] 284 (1939); **19** [1] 34 (1940); see "Silicosis. . . ," p. 108. M.H.

Problems in dust determination. H. LANDSBERG. *Penna. Dept. Labor & Ind., Safe Practice Bull.*, No. 24, 6 pp. (1940).—Numerous methods are considered, and their inadequacies are pointed out. L. shows that many questions in this field are still unanswered and that all standards should, for the present, be treated as tentative. F.S.M.

Rapid method for the estimation of air dustiness. HELMUTH H. SHRENK. *Amer. Jour. Pub. Health*, **30** [10] 1183–90 (1940).—To obtain comparable results the same procedure should be used, as results obtained by different methods are not always comparable. The impinger method is generally used because most dust-concentration limits were established with this method. S. lists numerous methods with references describing their manipulation. Methods which do not depend upon the collection of a dust sample do not give accurate results, because particle size, color, fog, mists, and low dust concentrations are measured with difficulty. An interpretation of dust estimations should be based on an understanding of atmospheric conditions, work schedule, plant operation, physiological effects of dusts, and limitations of the method used. B.C.R.

Record card for industrial cases. A. MARCUS. *Ohio State Med. Jour.*, **36**, 971–73 (Sept., 1940).—Facsimiles of four record forms are submitted for the purpose of overcoming frequent misunderstandings between patient, attending physician, and the Industrial Commission (Ohio). The first card is to contain, on one side, a complete history of the accident and is to be signed by the patient; the reverse side provides for an accurate record of dates, progress notes, etc. The second card is the company card and provides complete information as to time, nature, diagnosis, treatment, and probable duration of disability. The third card provides space for stamping the date and hour of each visit to the doctor's office. Upon his discharge the patient is to take the third card to his employer; this eliminates possible disputes as to the number of visits. These cards are very useful in providing the Commission with full and accurate information. F.S.M.

Report on Ceramic Engineering Education. J. W. WHITTEMORE, *Chairman*. *Bull. Amer. Ceram. Soc.*, **20** [2] 67–69 (1941).

Review of the clayworking industry. A. J. C. WATTS. *Claycraft*, **13** [8] 231–37 (1940).—W. reviews the brick industry in England from 1914 to the present time. The effects of the war are stressed, and the position of the brick industry in the future is discussed. G.A.K.

Searching the literature of science. E. LANCASTER JONES. *Jour. Sci. Instruments*, **17** [11] 253–57 (1940).—J. considers means of carrying out a search of scientific literature for information on a specific problem or type of problem. He discusses the types of publications, the normal procedure of searching, the inverse method of searching, guiding principles, available bibliographical resources, the Universal Decimal Classification, abstracting and indexing journals, and obtaining original records. J.L.G.

Serial chest roentgenograms of 3179 office employees, 1926–1938. H. H. FELLOWS. *Jour. Ind. Hyg. & Toxicol.*, **22**, 157–68 (May, 1940).—The first X-ray examination of this group was made between 1926 and 1932. Those whose first X ray was suggestive of pulmonary tuberculosis were not included, and the others were divided into three groups: (1) those with "negative" chests, (2) those with apparently healed primary complexes, and (3) those with lesions requiring further clinical study. Serial routine roentgenograms were made at varying intervals, and the results have been tabulated. When the development rate of pulmonary tuberculosis of those with "negative" chests was compared with that of the employees whose first X ray showed a healed primary complex, no significant difference was found. It is believed that roentgenographic examination is essential in any study of the lungs. F.S.M.

Testing of dust masks. O. M. FABER. *Staub*, No. 10, pp. 238–46 (Nov., 1939); abstracted in *Bull. Hyg.*, **15**, 345–46 (June, 1940).—F. reviews a previous article on the testing of filters and dust masks for their efficiency in trapping dust (*Staub*, No. 3, p. 344 (1936)). He describes the apparatus used for testing in detail. Breathing through the mask is brought about by a specially con-

structed artificial lung consisting of a pump, the stroke volume and rate being regulated to the respiratory volume and rate of man in different conditions of activity. Samples of the dust-air mixture can be taken before and after passing through the artificial head, and special precautions are necessary with regard to the times at which samples are taken. The dust is measured photoelectrically. Details of the method are to be given in a future communication. F.S.M.

Test methods and specifications. G. A. BOLE. *Ohio State Univ. Eng. Expt. Sta. News*, **12** [5] 21–23 (1940). W.D.F.

Treatment of injuries from fluoric acid in the glass industry. ZSCHACKE. *Diamant*, **61** [29–30] 275–76; [31] 285–86 (1939); see *Ceram. Abs.*, **19** [4] 102 (1940). M.H.

Use of the employee's suggestion box in glass factories. J. N. MARTIN. Presented at Sixth Conference on Glass Problems, University of Illinois, May 10, 1940; abstracted in *Glass Ind.*, **21** [6] 288 (1940). A.P.

Variations in excitability in experimental lead poisoning paralysis in guinea pigs and the action of sodium thiosulfate. L. BINET, P. CHAUCHARD, AND L. PEREL. *Compt. rend. soc. Biol.*, **133**, 563–65 (1940).—Sodium thiosulfate prevents damage to the nerve cells by counteracting the toxic action of lead salts, and no paralysis occurs. F.S.M.

Welfare and accident prevention. P. SPRIGGS. *Clay-craft*, **13** [11] 309–10 (1940). G.A.K.

BOOKS AND SEPARATE PUBLICATIONS

Detection of Toxic Gases in Industry—Carbon Monoxide. *Dept. Sci. Ind. Research Leaflet*, No. 7 (1939). Price 1s 6d net.—The estimation of small amounts of carbon monoxide in the atmosphere usually depends on one of the three following reactions: (*a*) reaction with the hemoglobin in blood, accurate but not suitable for general use; (*b*) reaction with iodine pentoxide liberating iodine, accurate but not suitable for routine use; (*c*) reduction of palladium chloride to the metal. The test paper moistened with the solution becomes stained, and the stains are compared with standards. This is the method recommended. A.B.S.

Industrial Survey of Ohio. Ohio Dept. Health, Adult Hygiene Div., Columbus, 1940. 291 pp.—This survey, conducted in cooperation with the U. S. Public Health Service, tabulates the number of workers exposed to potential health hazards and summarizes the protective measures available to these workers. It covers 2901 industries with a total of 300,674 employees which includes as much as 50% of some industries and as little as 10% of others. Those industries which are considered to be relatively free from occupational disease hazards are omitted. Of the establishments, 97.5% with 49.8% of the working population employs less than 500 workers. Establishments of less than 500 employees are usually not economically able to cope with industrial disease problems unassisted. This shows the need of official and unofficial industrial hygiene organizations. F.S.M.

Pneumoconiosis Among Mica and Pegmatite Workers. W. C. DREESEN, J. M. DALLA VALLE, T. I. EDWARDS, H. F. EASOM, AND M. F. TRICE. *U. S. Pub. Health Bull.*, No. 250, 73 pp. (1940); reviewed in *U. S. Pub. Health Repts.*, **55** [32] 1459–60 (Aug., 1940). K.R.

Problems of Workmen's Compensation Administration in the United States and Canada. M. DAWSON. *U. S. Dept. Labor, Bur. Labor Statistics, Bull.*, No. 672, 229 pp. (1940).—An extensive analysis of the methods of administration of compensation laws is presented. The entire report is a most valuable compilation for anyone interested in any phase of workmen's compensation. F.S.M.

Sick Absenteeism in Industry, Its Extent, Causes, and Control. *Air Hygiene Foundation of America, Inc., Medical Series, Bull.*, No. 4, 29 pp. (Feb., 1940). **Sick absenteeism.** A. J. LANZA AND R. J. VANE. Pp. 2–6. **Absenteeism reporting in the Portland cement industry.** A. J. R. CURTIS. Pp. 7–20. **Proposed plan for the recording of industrial absenteeism.** NATIONAL INSTITUTE OF HEALTH, DIVISION OF INDUSTRIAL HYGIENE, U. S. PUBLIC HEALTH SERVICE. Pp. 21–29.—Suggested charts for recording absences are presented. Discussions of the papers and a selected list of references are included.

Silicosis. Proceedings of the Second International Conference on Silicosis, Geneva, 1938. *Internat. Labor Office* (Geneva) *Studies and Repts., Series F*, No. 17, 102 pp. Appendices, 118 pp. Published by P. S. King and Son, Ltd., London, 1940. Distributed in the U. S. by the International Labour Office, 734 Jackson Place, Washington, D. C.—A round-table discussion of the papers presented is given. The following papers are published in the Appendices: **I, Biochemistry of silicosis.** A. H. VOSSENAAR. Pp. 105–107. **II, Protective action of various minerals against free silica.** LEROY U. GARDNER AND THOMAS M. DURKAN. Pp. 108–23. **III, Anthracosilicosis among hard-coal miners.** R. R. SAYERS. Pp. 124–33. **IV, Three communications on the effect of mixed dusts.** E. L. MIDDLETON. Pp. 134–39. **V, Belgian miners' silicosis.** A. LANGELEZ. Pp. 140–50. **VI, Silicosis.** L. G. IRVINE. Pp. 151–66. **VII, Silica in body fluids in relation to silicosis.** E. J. KING. Pp. 167–68. **VIII, Investigations on dust with special reference to the thermal precipitator.** H. S. PATTERSON. Pp. 169–83. See *Ceram. Abs.*, **19** [1] 34 (1940). **IX, Silicosis in Switzerland.** FRITZ LANG. Pp. 184–90. **X, Early diagnosis of silicosis.** R. R. SAYERS. Pp. 191–203. **XI, Measures of prevention of silicosis in Dutch coal mines.** A. H. VOSSENAAR. Pp. 204–207. **XII, Prevention of silicosis by metallic aluminum.** J. J. DENNY, W. D. ROBSON, AND DUDLEY A. IRWIN. Pp. 208–10. See *Ceram. Abs.*, **18** [10] 284 (1939); **19** [1] 34 (1940). **XIII, Depression of silica solubility in body fluids by mineral dusts.** E. J. KING, W. ROMAN, AND M. MCGEORGE. Pp. 211–17. **XIV, Determination of the properties which masks should possess.** A. H. VOSSENAAR. Pp. 218–20. See "Second . . .," *Ceram. Abs.*, **18** [11] 314 (1939). K.R. + F.G.H.

PATENT

Producing impervious sintered articles. ROSENTHAL-ISOLATOREN G.M.B.H. Ger. 680,205, Aug. 3, 1939 (April 21, 1936); VI/80*b*. 12.05.—Sericite, alone or in combination with talc, is employed as a drying agent. D.A.B.

THE AMERICAN CERAMIC SOCIETY TRUSTEES AND OFFICERS FOR 1941–1942

President: J. L. Carruthers, Ohio State University, Columbus, Ohio
Vice-President: J. T. Littleton, Corning Glass Works, Corning, N. Y.
Treasurer: C. Forrest Tefft, The Claycraft Co., Box 866, Columbus, Ohio
Secretary-Editor: R. C. Purdy, 2525 North High St., Columbus, Ohio
Past-President: A. I. Andrews, University of Illinois, Urbana, Ill.
Past-President: V. V. Kelsey, Dominion Minerals, Inc., Shoreham Bldg., Washington, D. C.

TRUSTEES FROM INDUSTRIAL DIVISIONS*

Art: L. E. Barringer, General Electric Co., Schenectady, N. Y. (1943)
Enamel: J. E. Hansen, Ferro Enamel Corp., Cleveland, Ohio (1943)
Glass: D. E. Sharp, Hartford-Empire Co., Hartford, Conn. (1941)
Materials and Equipment: H. B. DuBois, Consolidated Feldspar Corp., Trenton, N. J. (1942)
Refractories: J. D. Sullivan, Battelle Memorial Inst., Columbus, Ohio (1943)
Structural Clay Products: A. F. Greaves-Walker, Univ. of North Carolina, Raleigh, N. C. (1942)
Terra Cotta: F. B. Ortman, Gladding, McBean & Co., Los Angeles, Calif. (1942)
White Wares: E. H. Fritz, Westinghouse Electric & Mfg. Co., Derry, Pa. (1941)
Institute of Ceramic Engineers: R. E. Birch, Harbison-Walker Refractories Co., Pittsburgh, Pa. (1941)
Ceramic Educational Council: A. S. Watts, Dept. of Ceramic Engineering, Ohio State Univ., Columbus, Ohio (1941)

* Date of expiration of term of office in parentheses.

DIVISION OFFICERS

Art
Chairman: H. S. Nash, Univ. of Cincinnati, Cincinnati, Ohio
Secretary: C. C. Engle, United Clay Mines Corp., Trenton, N. J.

Enamel
Chairman: J. D. Tetrick, Baltimore Enamel & Novelty Co., Baltimore, Md.
Secretary: D. G. Bennett, Mellon Institute, Pittsburgh, Pa.

Glass
Chairman: W. R. Lester, Maryland Glass Corp., Baltimore, Md.
Secretary: S. R. Scholes, N. Y. State College of Ceramics, Alfred, N. Y.

Materials and Equipment
Chairman: B. T. Bonnot, The Bonnot Co., Canton, Ohio
Secretary: S. S. Cole, National Lead Co., Titanium Div., Research Lab., South Amboy, N. J.

Refractories
Chairman: J. B. Austin, U. S. Steel Corp., Kearny, N. J.
Secretary: R. S. Bradley, A. P. Green Fire Brick Co., Mexico, Mo.

Structural Clay Products
Chairman: H. Z. Schofield, O.S.U. Eng. Expt. Sta., Columbus, Ohio
Secretary: L. R. Whitaker, Richland Shale Products Co., Richtex, S. C.

White Wares
Chairman: Harry Thiemecke, Homer Laughlin China Co., Newell, West Va.
Secretary: Ralston Russell, Jr., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

OFFICERS OF THE FELLOWS

Dean: Edward Schramm, Onondaga Pottery Co., Syracuse, N. Y.
Associate Dean: T. A. Klinefelter, National Bureau of Standards, Washington, D. C.
Secretary-Treasurer: T. N. McVay, University of Alabama, University, Ala.

INSTITUTE OF CERAMIC ENGINEERS

President: H. G. Wolfram, Porcelain Enamel & Mfg. Co., Baltimore, Md.
Vice-President: E. H. Fritz, Westinghouse Electric & Mfg. Co., Derry, Pa.
Secretary: H. M. Kraner, Research Dept., Bethlehem Steel Co., Bethlehem, Pa.

CERAMIC EDUCATIONAL COUNCIL

President: M. E. Holmes, N. Y. State College of Ceramics, Alfred, N. Y.
Secretary: P. G. Herold, Missouri School of Mines, Rolla, Mo.

LOCAL SECTIONS

Baltimore-Washington
Chairman: Kenneth M. Smith, Severn Clay Co., Baltimore, Md.
Secretary: W. R. Lester, Maryland Glass Corp., Baltimore, Md.

Central Ohio
Chairman: C. J. Koenig, O.S.U. Eng. Expt. Sta., Columbus, Ohio
Secretary: M. C. Shaw, Edward Orton, Jr., Ceramic Foundation, Columbus, Ohio

Chicago
Chairman: E. E. Blankenstein, Western Electric Co., Cicero, Ill.
Secretary: C. R. Filippi, Illinois Brick Co., Chicago, Ill.

Michigan-Northwestern Ohio
Chairman: R. O. Lane, Macklin Co., Jackson, Mich.
Secretary: J. F. Quirk, A C Spark Plug Co., Flint, Mich.

Northern California
Chairman: T. K. Cleveland, Philadelphia Quartz Co., Berkeley, Calif.
Secretary: L. G. Larsen, A. J. Lynch & Co., San Francisco, Calif.

Pacific-Northwest
President: M. D. Saindon, Chehalis Brick & Tile Co., Chehalis, Wash.
Secretary: C. H. Zwermann, Univ. of Washington, Seattle, Wash.

Pittsburgh
Chairman: C. L. Thompson, Harbison-Walker Refractories Co., Pittsburgh, Pa.
Secretary: L. A. Smith, Jones & Laughlin Steel Corp., Aliquippa, Pa.

Southern California
Chairman: J. G. Stewart, Braun Corp., Los Angeles, Calif.
Secretary: R. H. Martin, Vernon Potteries, Ltd., Los Angeles, Calif.

St. Louis
Chairman: H. H. Hanna, Pittsburgh Plate Glass Co., Crystal City, Mo.
Secretary: J. H. Ivery, Hydraulic Press Brick Co., St. Louis, Mo.

OFFICIAL PERSONNEL OF DIVISIONS, 1940–1941

	Art	Enamel	Glass	Materials and Equipment	Refractories	Structural Clay Products	White Wares
Trustee	L. E. Barringer	J. E. Hansen	D. E. Sharp	H. B. DuBois	J. D. Sullivan	A. F. Greaves-Walker	E. H. Fritz
Chairman	H. S. Nash	J. D. Tetrick	W. R. Lester	B. T. Bonnot	J. B. Austin	H. Z. Schofield	Harry Thiemecke
Vice-Chairman	K. E. Smith		A. K. Lyle	W. H. Emerson	Gilbert Soler	J. H. Isenhour	
2nd Vice-Chairman			W. C. Taylor				
Secretary	C. C. Engle	D. G. Bennett	S. R. Scholes	S. S. Cole	R. S. Bradley	L. R. Whitaker	R. Russell, Jr.
Society Nominations A.....	M. M. French	B. T. Sweely	F. C. Flint	W. R. Malkin	G. A. Bole	R. L. Stone	L. E. Thiess
Society Nominations B.....	C. C. Engle	R. R. Danielson	W. M. Clark	H. R. Straight	S. M. Phelps	T. W. Garve	D. C. Zimmer
Division Nominations	Ruth Canfield A. A. Ayars	H. G. Wolfram	A. N. Finn				
Papers and Program	W. A. Weldon Carlton Atherton J. P. Thorley	R. L. Fellows	A. K. Lyle W. C. Taylor	S. S. Cole J. R. Kauffman R. Buchholz	C. L. Thompson W. R. McLain G. S. Diamond W. R. Kerr	H. D. Foster F. E. Lobaugh J. E. Rankin	F. C. Henderson Howard Failmezger C. G. Harman
Membership	H. E. Marley H. H. Sanders	Karl Kautz	C. B. Delgado	J. T. Robson	C. A. Freeman	J. H. Stewart	G. J. Bair
Standards	A. E. Baggs	F. W. C. Hutchison	G. W. Morey	W. H. Vaughan	P. S. Dear	H. C. Plummer	J. H. Koenig
Research	H. F. Bopp	R. J. Whitesell	N. W. Taylor	J. F. McMahon	D. W. Ross	Frederick Heath, Jr.	J. R. Beam
Data	Marion Fosdick P. E. Cox	P. C. McCollom	A. E. Badger	R. G. O'Meara	P. G. Herold	H. G. Schurecht	G. A. Loomis
Rules	Theodore Lenchner	G. H. Spencer-Strong	A. N. Finn	J. E. Eagle	R. B. Sosman	G. H. Duncombe, Jr.	K. E. Stettinius
Councillors	C. M. Harder A. E. Baggs	W. H. Pfeiffer R. D. Cooke	L. C. Roche F. C. Flint	V. V. Kelsey F. E. Finch		C. R. Austin T. W. Garve	F. P. Hall Karl Schwartzwalder
Exhibitions	Ruth Randall	*Bibliography* J. E. Rosenberg	R. M. Curts				
Industrial Management	F. H. Rhead				G. B. Remmey		